Biological Drawings
With notes

Parts 1 & 2

Maud Jepson

BIOLOGICAL DRAWINGS

WITH NOTES

By MAUD JEPSON, M.Sc. (Manchester)

(First Class Honours in Zoology)

With a Preface by

H. GRAHAM CANNON, M.A., Sc.D., F.R.S.

Professor of Zoology, The University, Manchester

PART I

1968

LONDON

JOHN MURRAY, ALBEMARLE STREET, W.

TO THE MEMORY OF MY MOTHER
EMILYNE MAUD JEPSON

First Edition 1938

Twenty-eighth impression 1982

0 7195 0726 x

Old price Rs 147/–
New Price Rs 289/–
5 chatters

PREFACE

THE considerable experience gained by Miss Jepson in teaching School Certificate pupils and candidates for higher examinations, has prompted her to produce this book of illustrations. Her object has been, not to minimize or cut out much of the practical work, but rather to enable the student to derive the greatest benefit from a period in the laboratory, which is always too short in the average school curriculum, and usually so even in the University. In both Botany and Zoology the execution of practical work is often long and difficult, but the time taken can be cut down, and the value derived from the dissection or preparation increased enormously when the student, by the aid of a well-labelled drawing, can see what to look for. Miss Jepson's work collects together, in a convenient form, actual drawings of her own preparations, which are realistic and not diagrammatic.

A criticism often levelled against the production of such drawings is that it provides the lazy pupil with something that can be copied, and the actual dissection maybe done not at all. This is admittedly so, but pupils of that level will always be with us, from the preparatory school up to the post-graduate. They cannot and should not be considered. In any case, these drawings of Miss Jepson's, taken as they are from actual dissections, would be difficult to memorize. They are not diagrams which can be remembered easily in a perfectly unintelligent manner. They provide simple drawings which the good student can have by him when he is carrying out his practical work, and by their excellence, provide him with a clear-cut key to the structures and arrangements he is expected to find in his practical work.

H. GRAHAM CANNON.

ACKNOWLEDGMENTS

THE completion of this work would not have been possible, had it not been for the kindness which I have received from many people.

My thanks are due to my friend Miss Elsie I. MacGill, M.Sc., and to my former Lecturer, Mr. W. O. Howarth, D.Sc., both of the Manchester University, for the time which they have so generously given in going through the first rough sketches, and later the finished drawings. Their suggestions and criticisms have been most valuable in the arrangement of this work.

I wish to thank Professor Graham Cannon, Sc.D., F.R.S., for writing the Preface, and also for the kindness he has shown, and the encouragement he has given me, in his criticism of the drawings.

I should like to record my indebtedness to Mr. Heasman, H.M.I., and Mr. Painter, H.M.I., for their helpful suggestions with regard to the publication of these volumes.

I express my gratitude to the Head Master, Mr. M. J. H. Cooke, M.Sc., in whose laboratory much preparation and practical work has been done, and to Mr. George Wood, M.Sc., Principal of the Stockport College for Further Education, whose interest in my drawing and teaching of the subject has been the source of constant encouragement, and also to Mr. Kendell for much advice with regard to the reproduction of such work.

Finally, I should like to thank the publishers for their courtesy and consideration at all times.

MAUD JEPSON.

May, 1938

For whatever improvements are to be found in this second edition I must again thank Miss Elsie I. MacGill and Dr. W. O. Howarth.

To Professor Graham Cannon I am much indebted for his valuable help and advice.

MAUD JEPSON.

February, 1939

CLASSIFICATION OF FRUITS

True fruits

- **Dry**
  - **Dehiscent**
    - One carpel
      - FOLLICLES: Delphinium, Columbine, Monkshood, Marsh Marigold etc.
      - LEGUMES: Laburnum, Bean, Pea, Lupin etc.
    - Two carpels
      - SILIQUAS: Stock, Wallflower
      - SILICULAS: Honesty, Candytuft, Shepherd's Purse etc.
    - Two or more carpels
      - CAPSULES: Poppy, Campanula, Snapdragon, Horse Chestnut, Campion, Evening Primrose, Violet, Scarlet Pimpernel
  - **Indehiscent**
    - One carpel
      - NUTS OR ACHENES: Acorn, Oak, Sweet chestnut, Beech, Rose, Strawberry, Hornbeam, Samara of Ash, Elm.
    - Two or more carpels
      - SCHIZOCARPS:
        - Double Samara of Sycamore etc.
        - Carcerulus of Mallow, Hollyhock, Hound's Tongue.
        - Cremocarp of Hogweed, Goutweed etc.
        - Lomentum of Bird's foot Trefoil etc.
- **Succulent (Indehiscent)**
  - One carpel [hard endocarp]
    - DRUPES: Plum, Cherry, Blackberry (collection of drupes), Coconut (fibrous exocarp)
  - Two or more carpels.
    - BERRIES.: Date (One seed), Orange, Gooseberry, Banana, Marrow

FALSE FRUITS OR PSEUDOCARPS.

False fruits are formed when some part other than the ovary wall develops as a result of fertilisation. e.g. receptacle, inflorescence.

Receptacle:- Strawberry (achenes)
Rose hip. (")
Apple.

Inflorescence:- Mulberry (achenes)
Pineapple.
Fig (drupes).

DISPERSAL OF FRUITS, SEEDS AND SPORES.

1. WIND.
   a) Small seeds and spores.
   b) Censer-mechanism e.g. Poppy.
   c) Increase in surface - with little increase in weight.
      (i) Seed parachutes e.g. Cotton
      (ii) Fruit parachutes. e.g. Dandelion.
      (iii) Winged seeds e.g. Pine.
      (iv) Winged fruits. e.g. Sycamore.
   d) Separation of carpels. e.g. Goutweed.
   e) Rolling of spheroidal fruits and seeds.

2. WATER
   a) Spongy aril in Water Lily
   b) Fibrous exocarp in Coconut.

3. ANIMALS
   a) Birds - Succulent seeds and fruits - false fruits.
   b.) Mammals (i) Hooked fruits and seeds.
      (ii) Nuts etc (Rodents only)
   c) Ants - Oily seeds. e.g. Gorse.
   d) Human traffic - e.g. shipping, forestry, wool manufacture etc.

4. PROPULSIVE OR EXPLOSIVE MECHANISM. - Here the construction of the fruit renders it independent of any of the above agencies.
   a) Tensions set up by the unequal drying of the pericarp e.g. Gorse, Violet, Geranium etc.
   b) (i) The turgidity of the pericarp e.g. Balsam.
      (ii) The turgidity of the aril e.g. Wood Sorrel.

M.W.M.J.

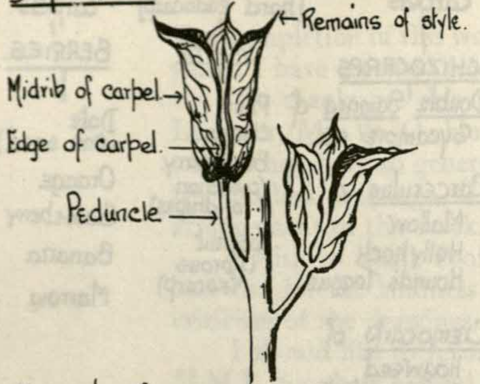
DISPERSAL OF FRUITS, SEEDS AND SPORES.

AGENTS :- WIND - WATER - ANIMALS - EXPLOSIVE OR PROPULSIVE MECHANISM

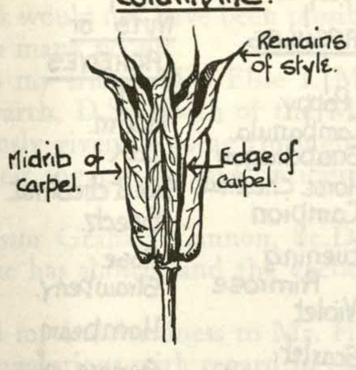
WIND a) Small spores - e.g. Fern, Fungi etc
Minute seeds, forming a powdery mass - In Orchid, a loose outer cover renders the seed more buoyant.

b) Censer - mechanism.

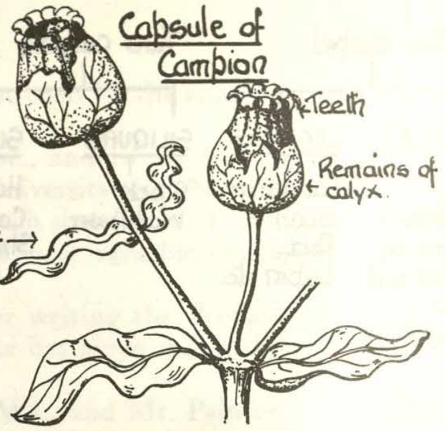
Follicles of Delphinium



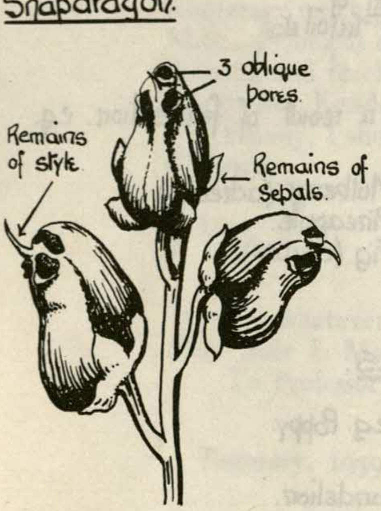
Follicles of Columbine.



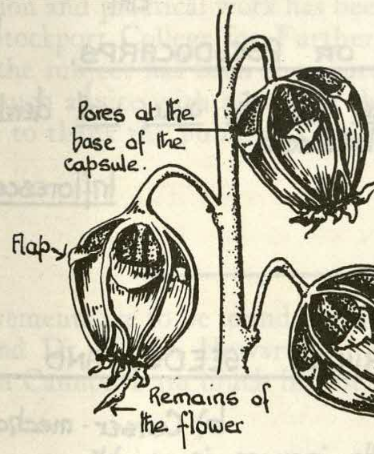
Capsule of Campion



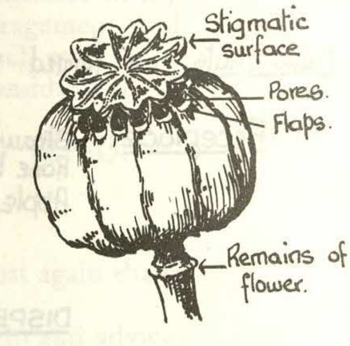
Capsule of Snapdragon.

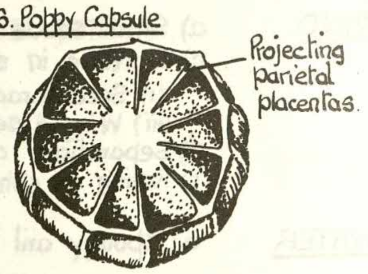


Capsule of Campanula.

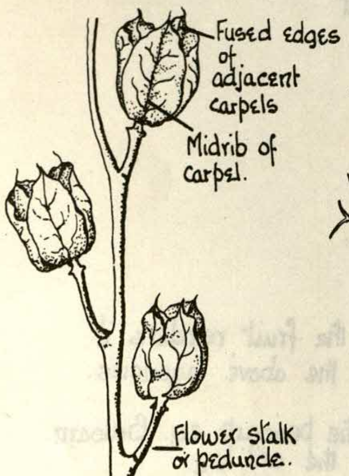


Capsule of Poppy.

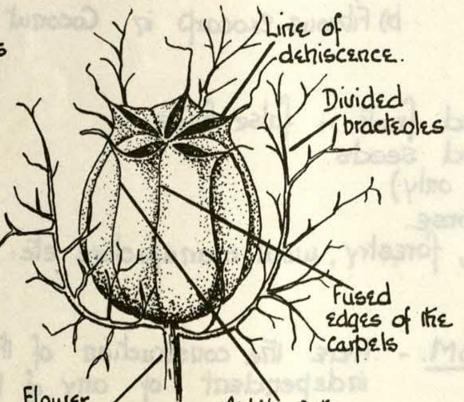




Capsule of Bluebell



Capsule of Nigella.



Capsule of Scarlet Pimpernel x6 (Pyxidium)

Capsule of Iris

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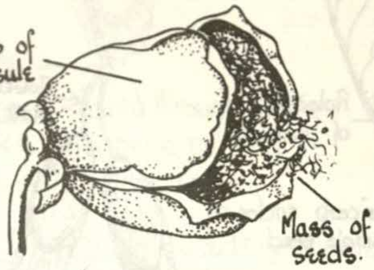
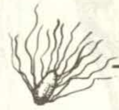
WIND. (continued) c) Increase in surface – Weight much the same.

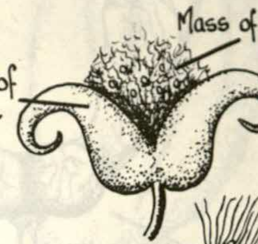
1. Seed parachutes

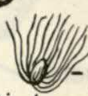
Capsule of Cotton.



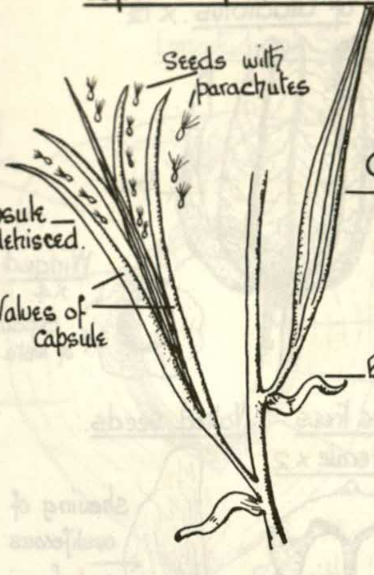


Capsule of Willow x6



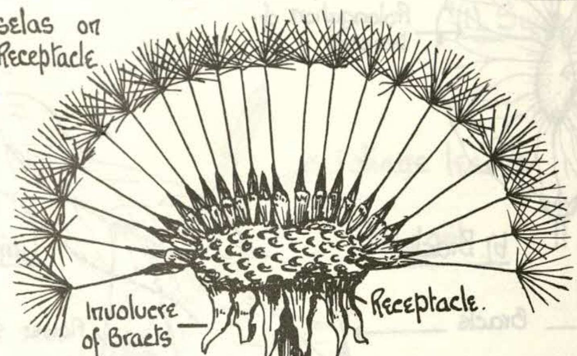


Capsule of Willow Herb.

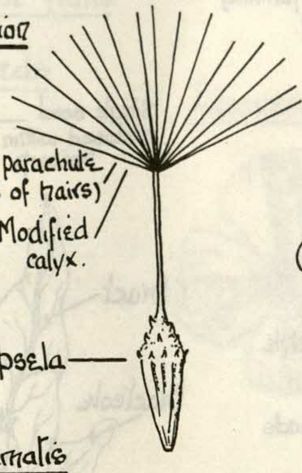


2. Fruit parachutes.

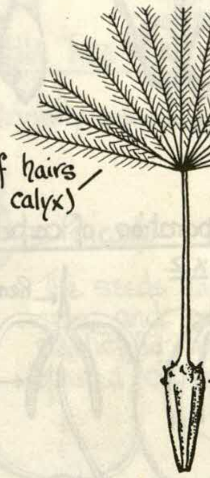
Dandelion (Cypsela)



Cypselas of Dandelion



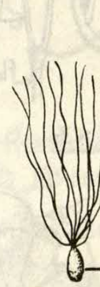
Goat's beard. (Cypsela)



Thistle. Cypsela.

Achenes of Clematis

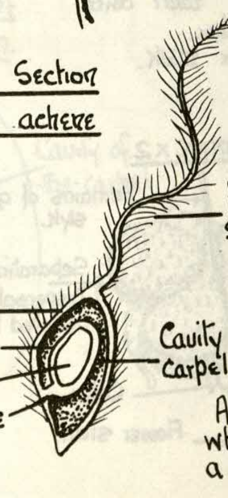
Cypselas of Cotton Sedge. (Cotton-grass)



Single fruit.

Achene of clematis

Longitudinal Section of Clematis achene



A Cypsela develops from an inferior ovary of two carpels while a true achene develops from a superior ovary of one carpel.

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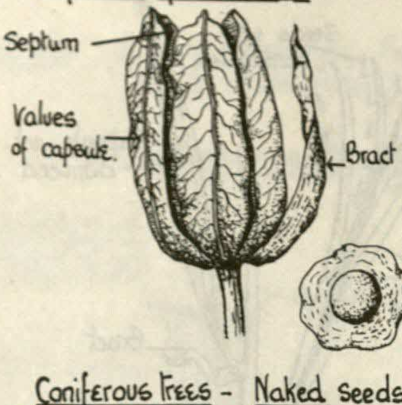
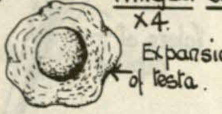
4. c) Increase in surface - Weight much the same (continued).

3. Winged seeds.

Capsule of Gladiolus. x 1½.

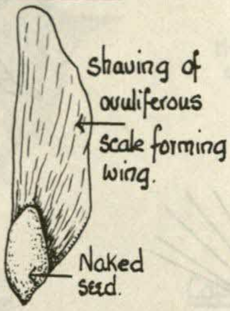


Winged seed x 4



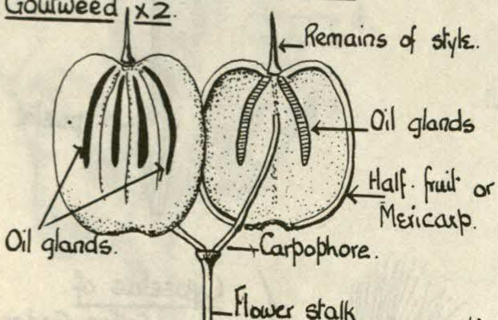
Coniferous trees - Naked seeds.

Ovuliferous scale x 2. (Pinus)

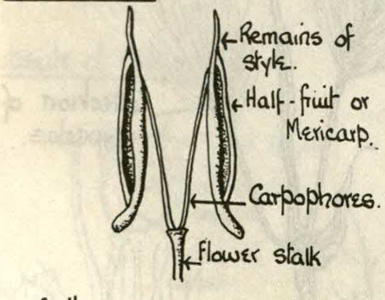


d) Separation of carpels.

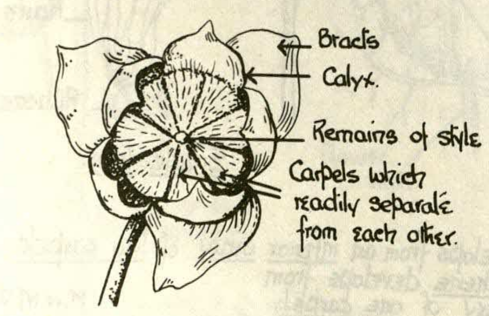
Goutweed x 2.



Goutweed x 2



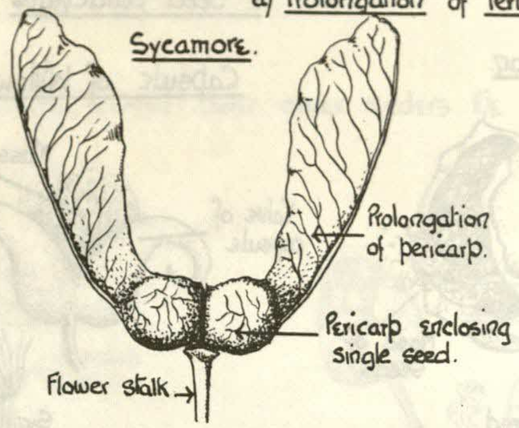
Mallow x 3



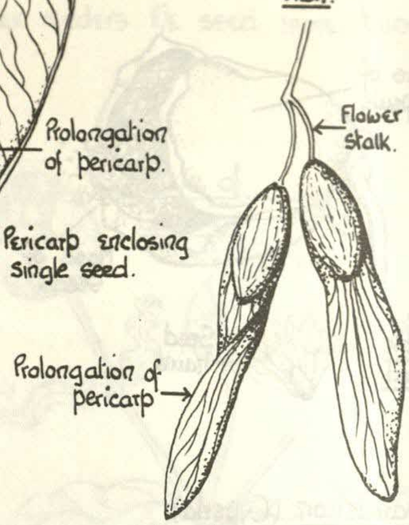
4. Winged fruits

a) Prolongation of Pericarp.

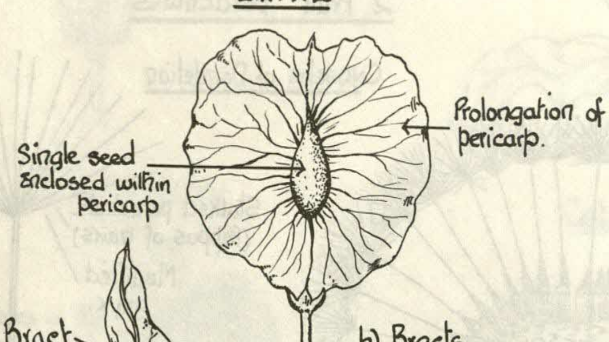
Sycamore.



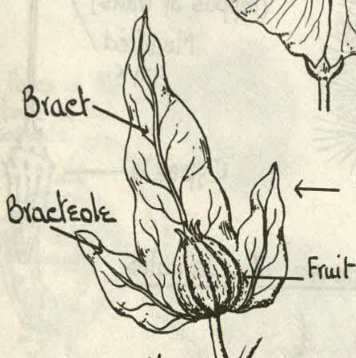
Ash.



Elm x 2

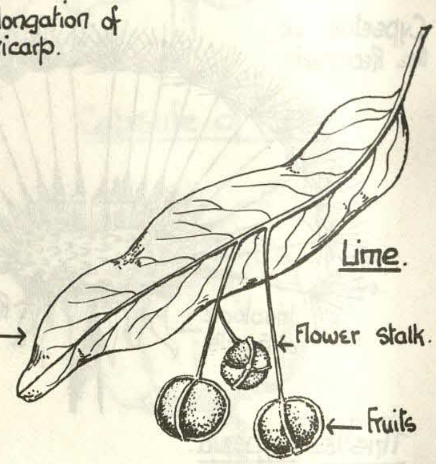


b). Bracts



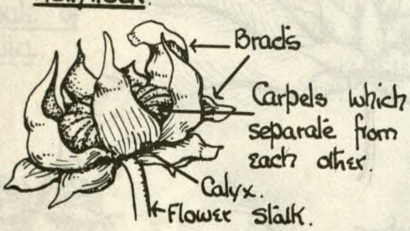
Horn-beam.

Lime.

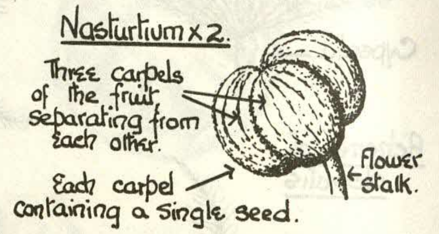


d) Separation of Carpels

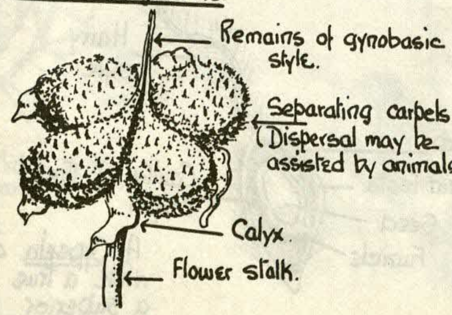
Hollyhock.



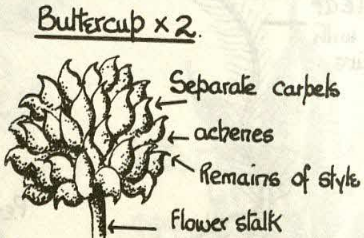
Nasturtium x 2.



Hound's Tongue x 2.



Buttercup x 2.



In Buttercup the achenes occur in groups so that a large multiple fruit (Etaerio) is produced by one flower.

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WATER.

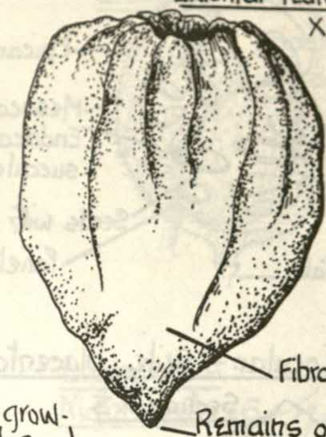
a) Spongy aril in Water Lily

Coconut - found throughout the tropics. Probably a native of the Indo - Malayan region

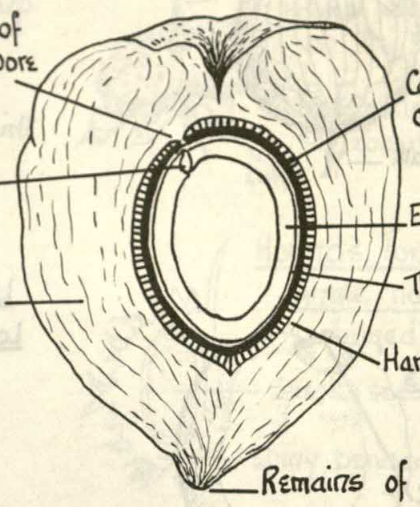
Red Mangrove - Seeds germinate on the parent tree (viviparous germination). Such offspring float in the sea, finally growing on a new stretch of sand.

b) Fibrous exocarp in Coconut

External Features $\times \frac{1}{8}$



Longitudinal Section $\times \frac{1}{8}$



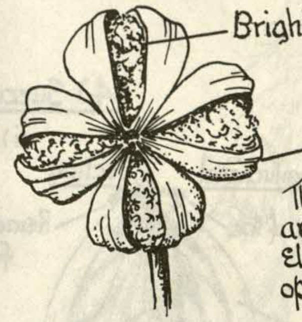
ANIMALS.

a) Birds - Succulent seeds and fruits - False fruits

(1) Succulent seeds

Yew $\times 2$.

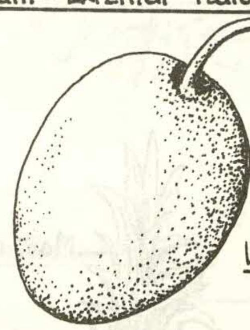
Japanese Spindle Tree $\times 2$



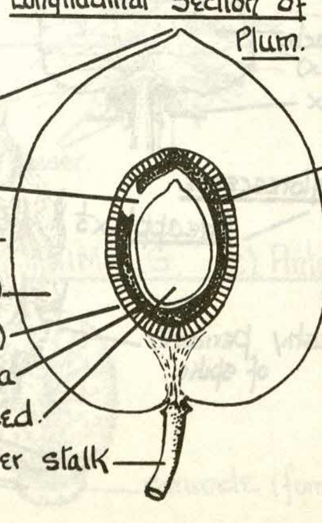
The seeds have bright red arils, and hang by their elastic funicles from the opened capsule.

(2) Succulent fruits (Drupes)

Plum - External Features



Longitudinal Section of Plum.

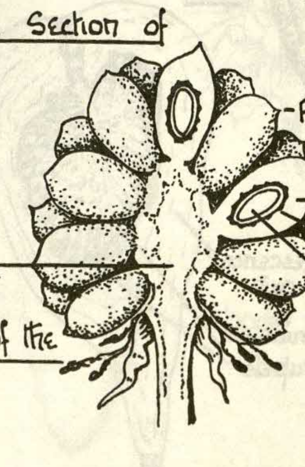


Blackberry - Collection of Drupels

External Features.

L.S. Single drupel

Longitudinal Section of Blackberry



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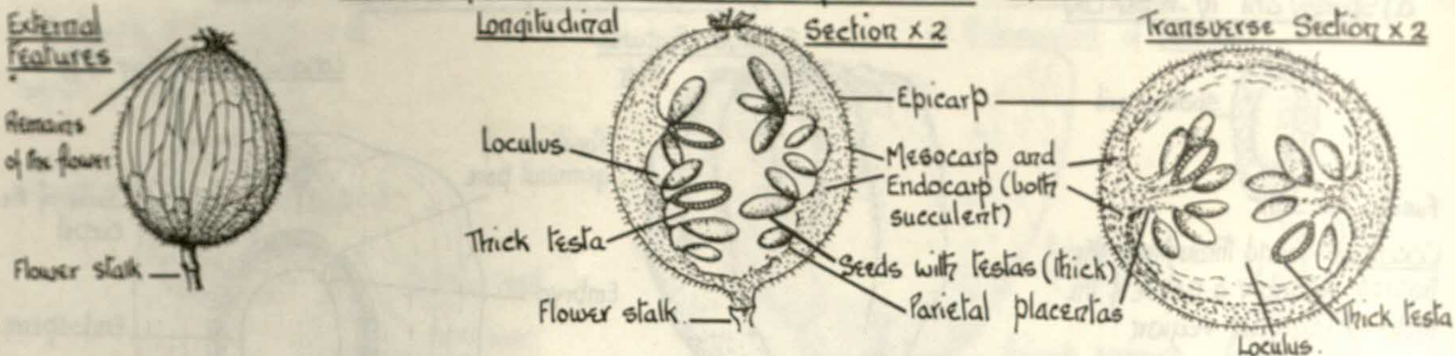
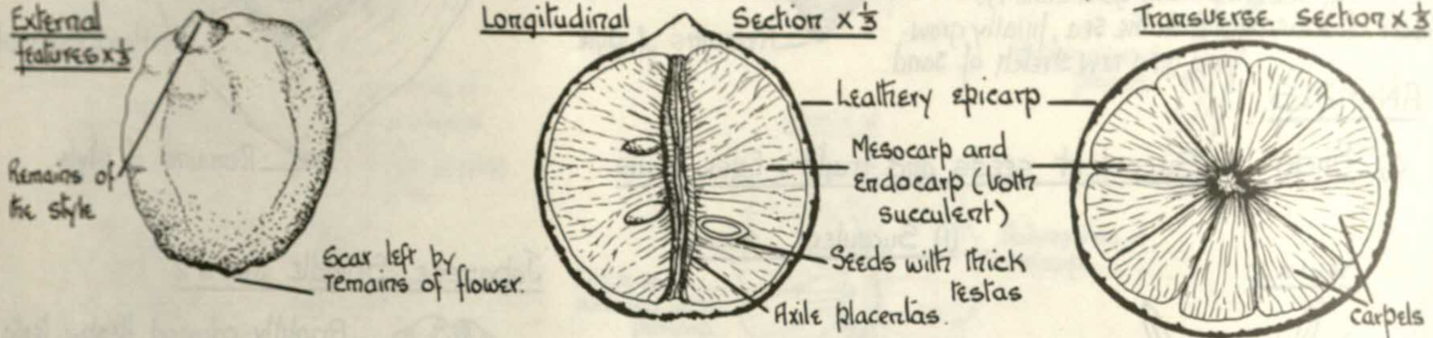
(3) Succulent fruits (Berries)

Gooseberry - Unilocular - Parietal placentation (Inferior ovary)

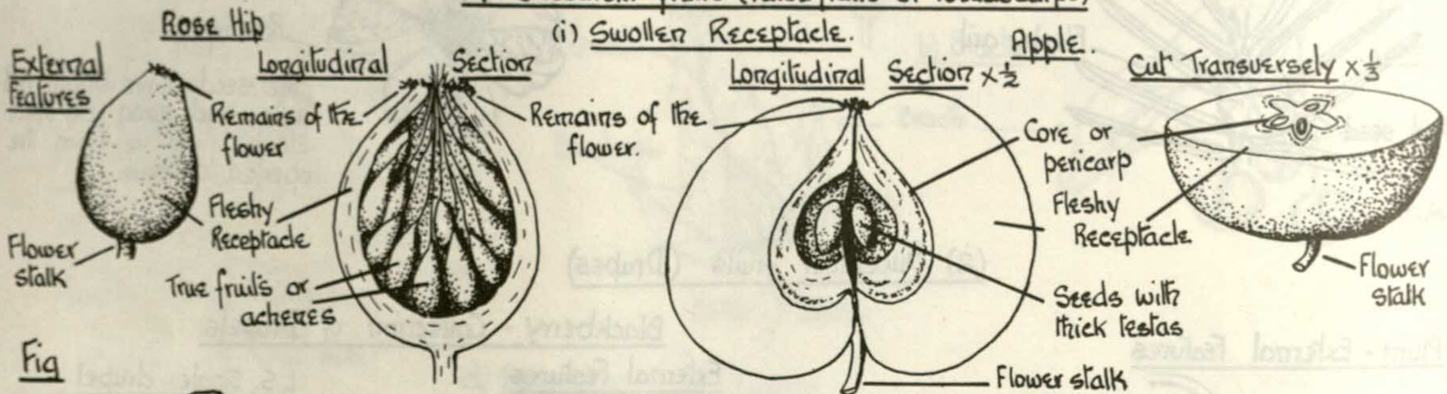


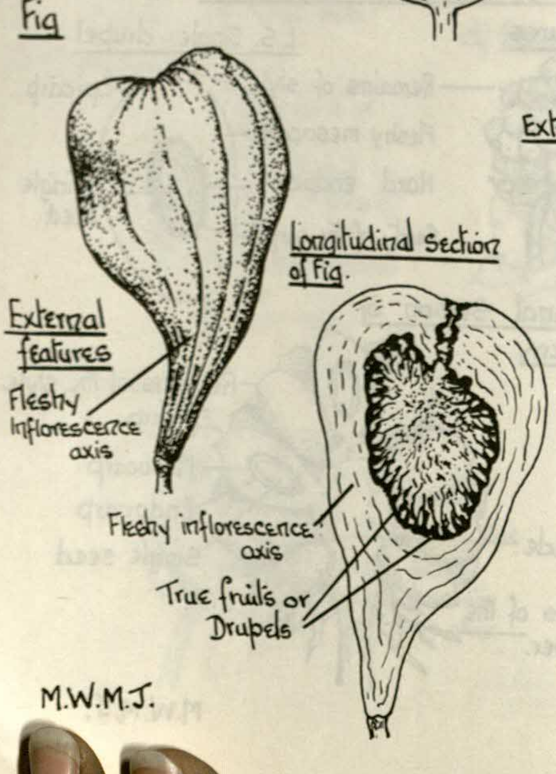
Lemon - Locular - Axile placentation (Superior ovary)

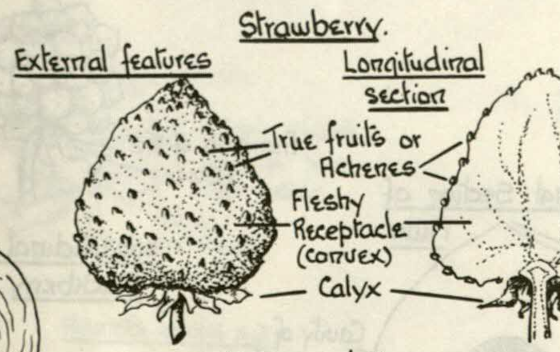


(4) Succulent fruits (False fruits or Pseudocarps)

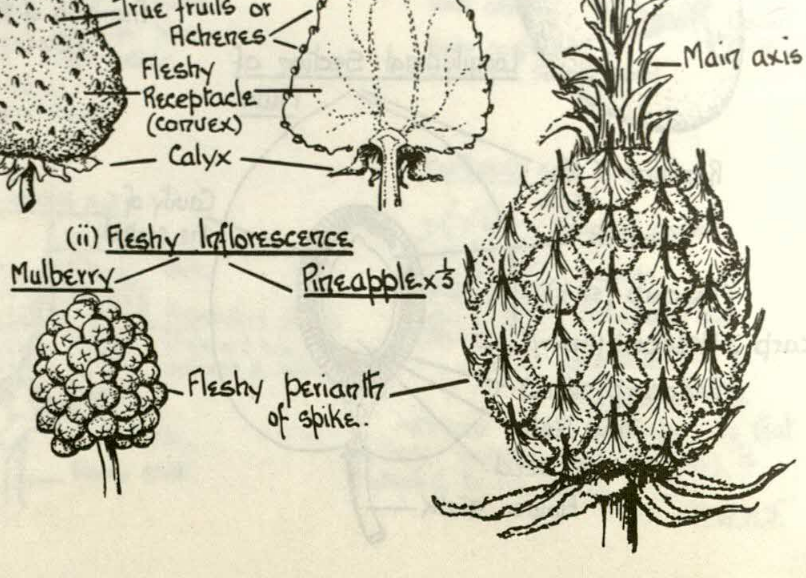
(i) Swollen Receptacle.







(ii) Fleshy Inflorescence



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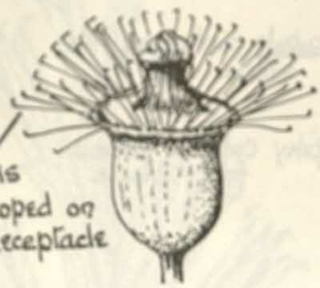
ANIMALS. b) Mammals - Hooked fruits and seeds

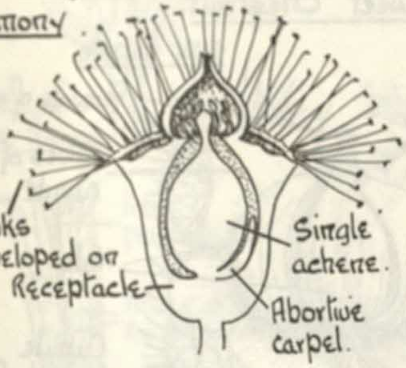
Agrimony x 5



Cleavers x 4

Hound's Tongue x 1½

Longitudinal Section of Agrimony

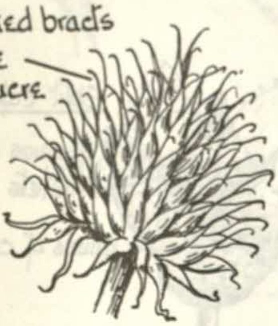


Enchanter's Nightshade x 6

Hound's Tongue
single nutlet
(enlarged)

Grapple fruit of South Africa
Reduced (from Hentschel and Cook)

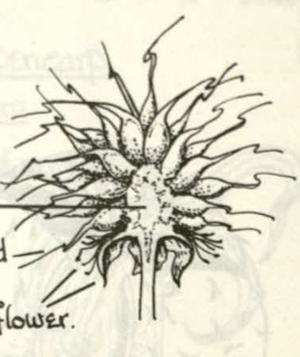
Burdock.



Burr Marigold.
x 3

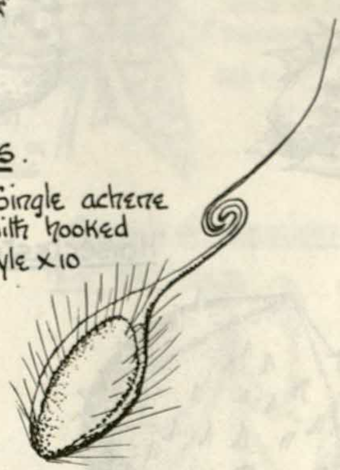
Avens

Longitudinal section



Avens.

Single achene
with hooked
style x 10

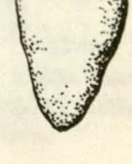


Avens. External features

ANIMALS. c) Ants - Oily seeds.

Castor Oil seed
x 1½

Gorse seed x 7



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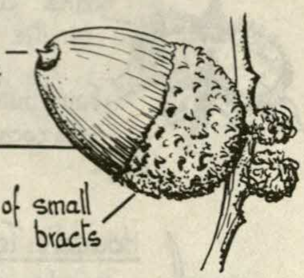
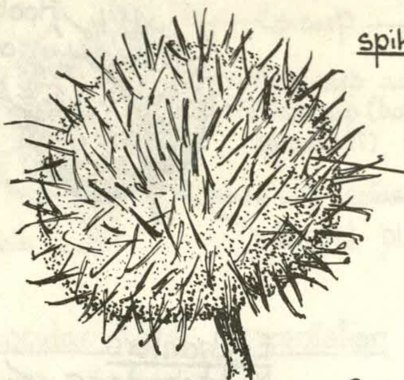
8. ANIMALS - d) Rodents - Nuts and Nutlets (Achenes)

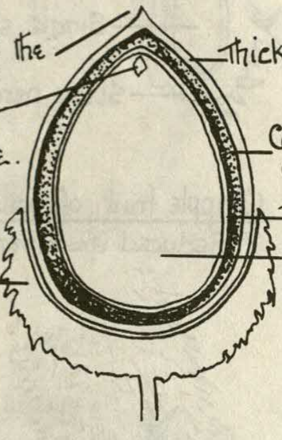
Nut of Oak
Acorn.



Nuts of Sweet chestnut.

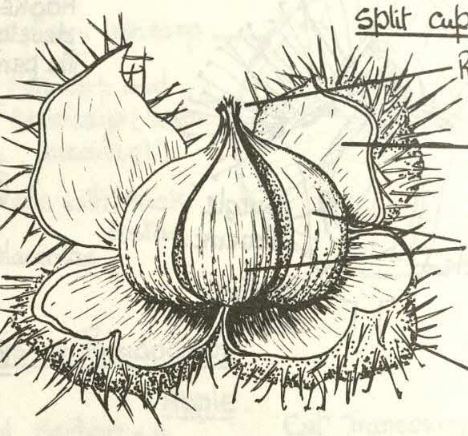


Longitudinal section of Acorn.



Sweet Chestnut.

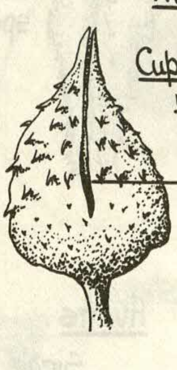
split cupule.



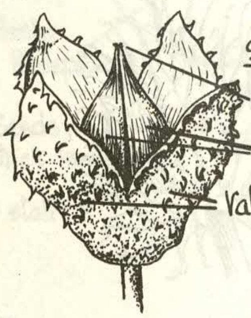
Nuts of Hazel.

Nutlets of Beech.

Cupule unopened.

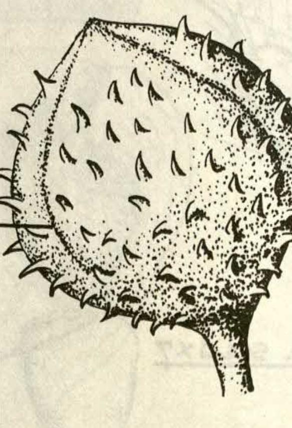


Split cupule.

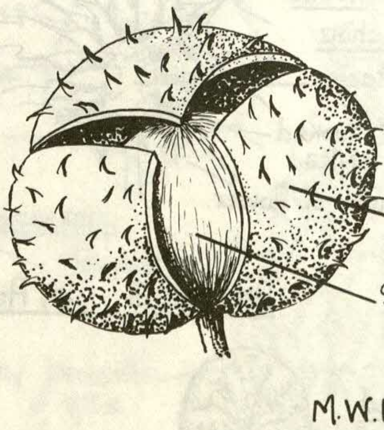


Horsechestnut.

Prickly capsule (unopened)

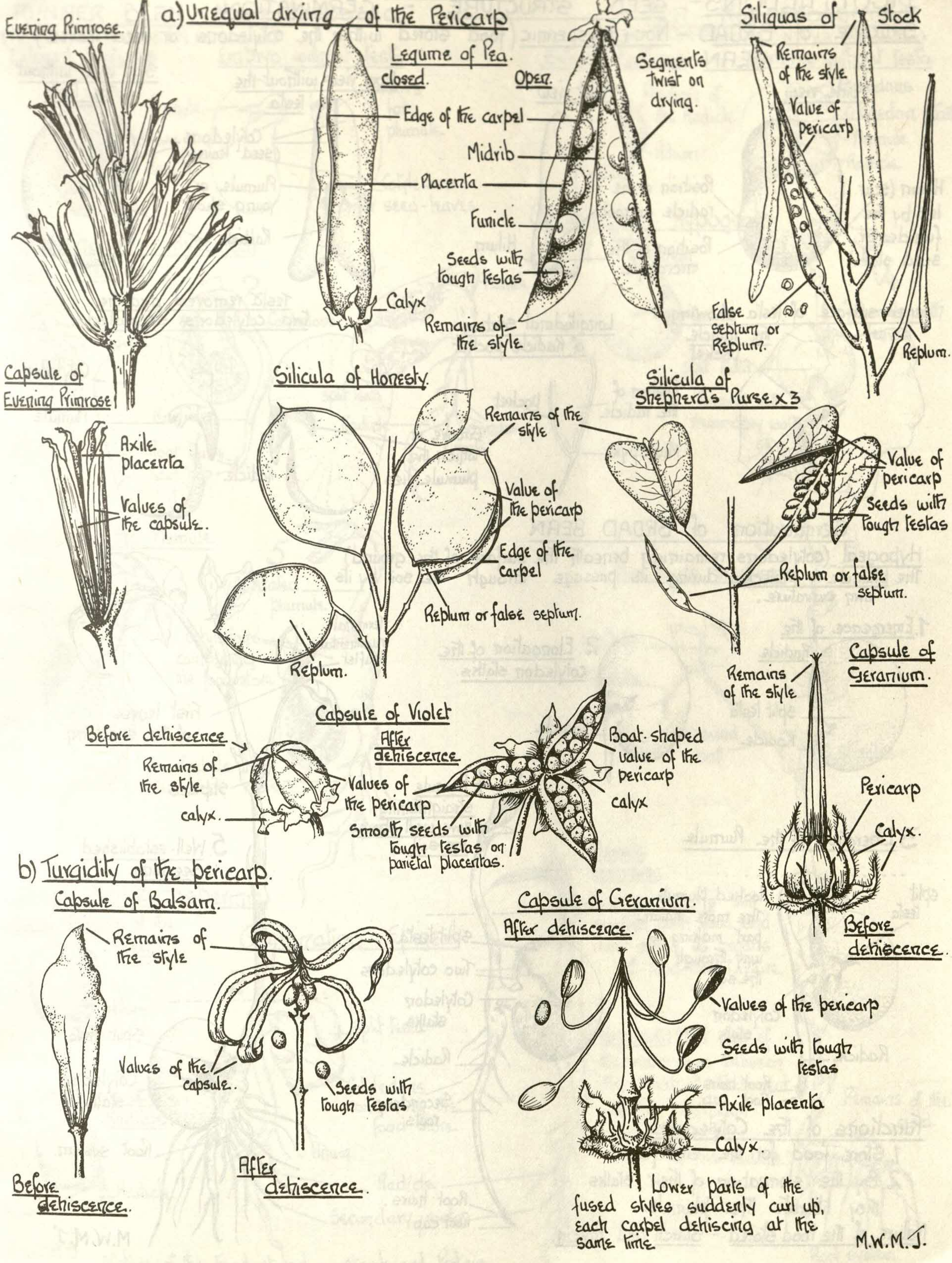


Split capsule.



M.W.M.J.

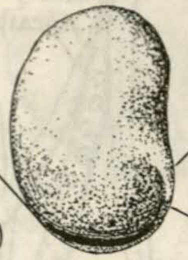
PROPULSIVE or EXPLOSIVE MECHANISM.



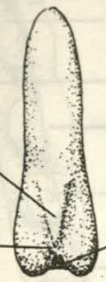
DICOTYLEDONS – SEED STRUCTURE – GERMINATION

Structure of BROAD BEAN – Non-endospermic (food stored within the cotyledons or seed-leaves)

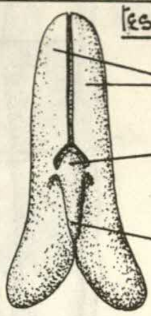
Side view



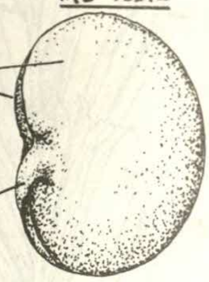
Front view.



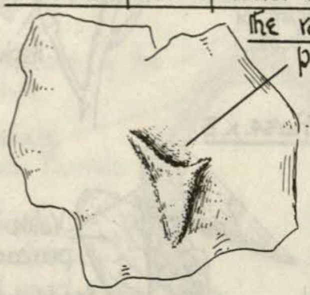
Front view, without the testa



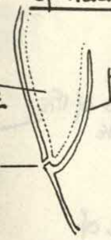
Side view without the testa



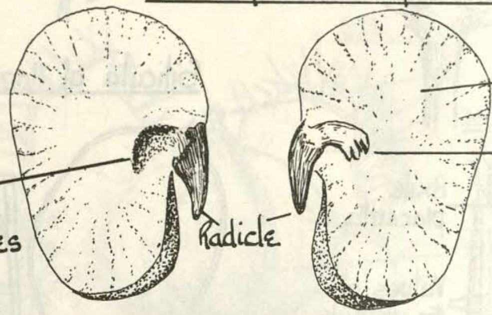
Inner surface of testa showing the radicle pocket.



Longitudinal section of Radicle pocket



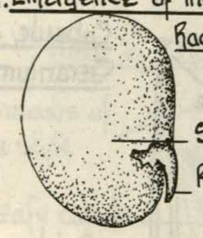
Testa removed, and the two cotyledons separated.



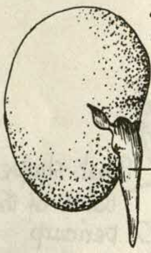
Germination of BROAD BEAN

Hypogeal (cotyledons remaining beneath the surface of the ground)
The plumule is protected during its passage through the soil by its own curvature.

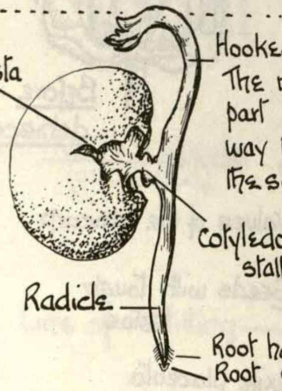
1. Emergence of the Radicle



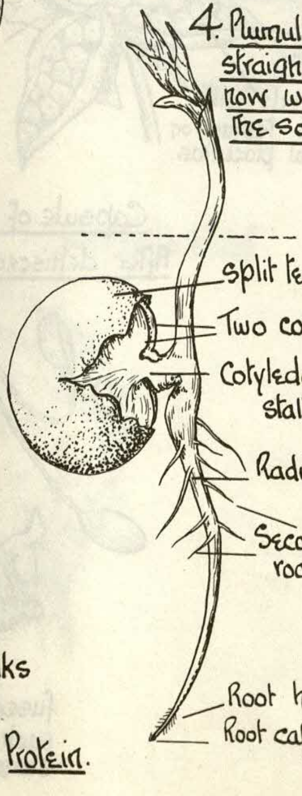
2. Elongation of the cotyledon stalks.



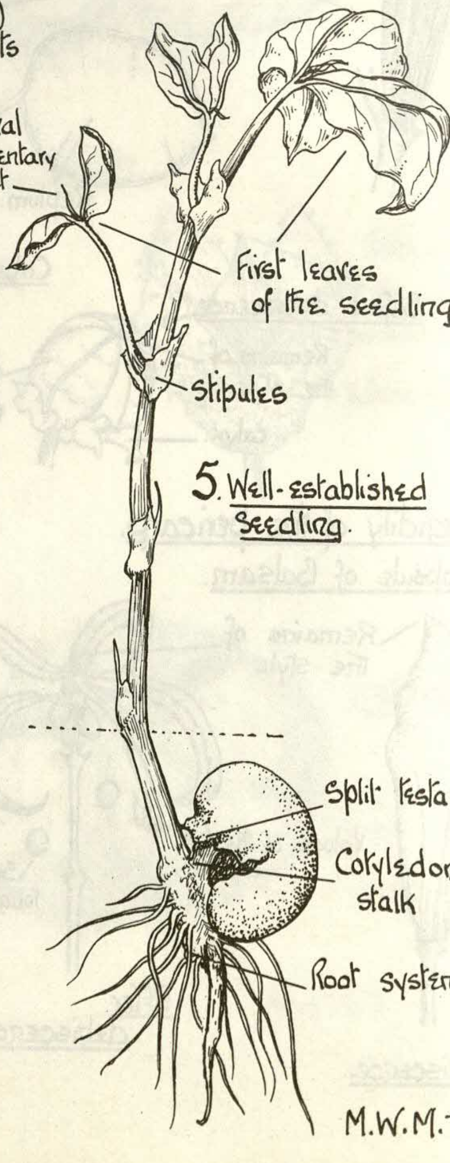
3. Liberation of the Plumule



4. Plumule straightening, now well above the soil



5. Well-established Seedling.



Functions of the Cotyledons

1. Store food for the embryo
2. By the elongation of their stalks they liberate the plumule.

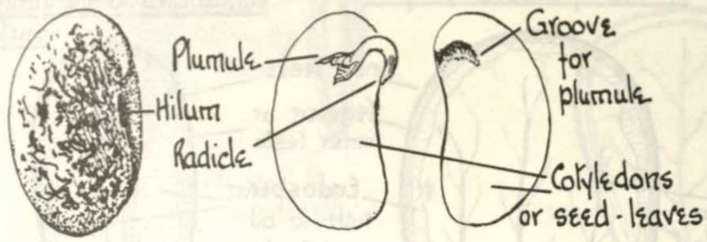
Nature of the Food stored – Starch and Protein.

M.W.M.J.

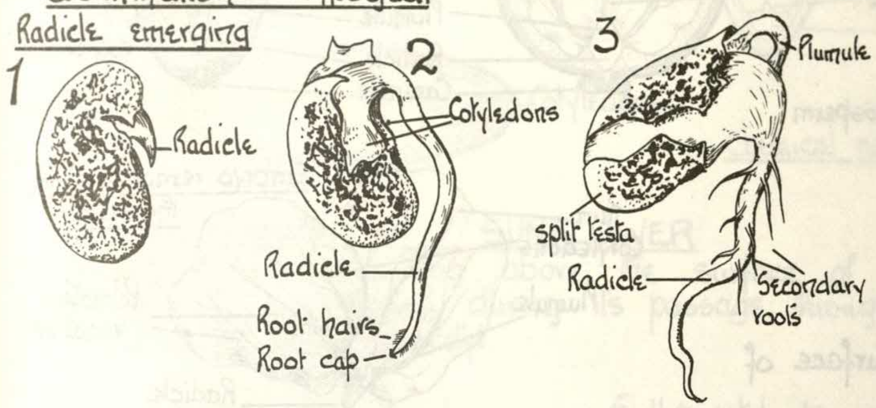
DICOTYLEDONS - SEED STRUCTURE GERMINATION

RUNNER BEAN - Non-endospermic
(AFRICAN YAM BEAN is similar)

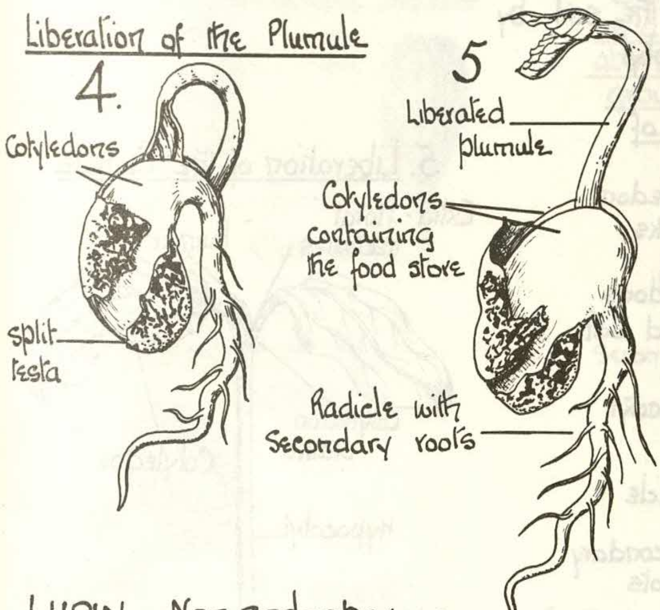
External Features — Embryo without testa



Germination - Hypogeal

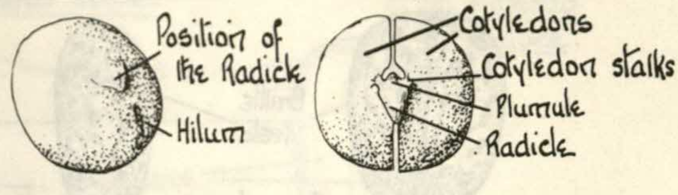


Liberation of the Plumule

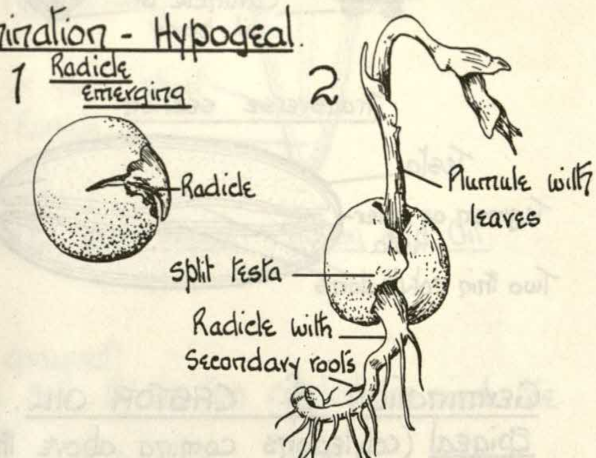


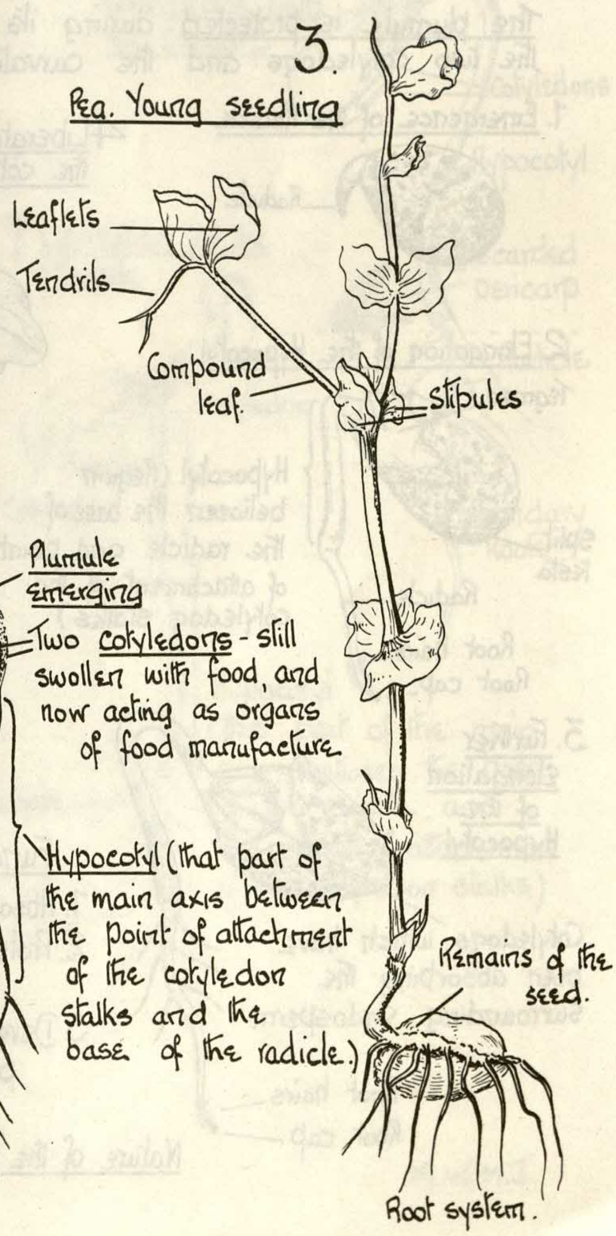
PEA - Non-endospermic
(CROTALARIA and COW-PEA are similar)

External Features — Embryo without testa

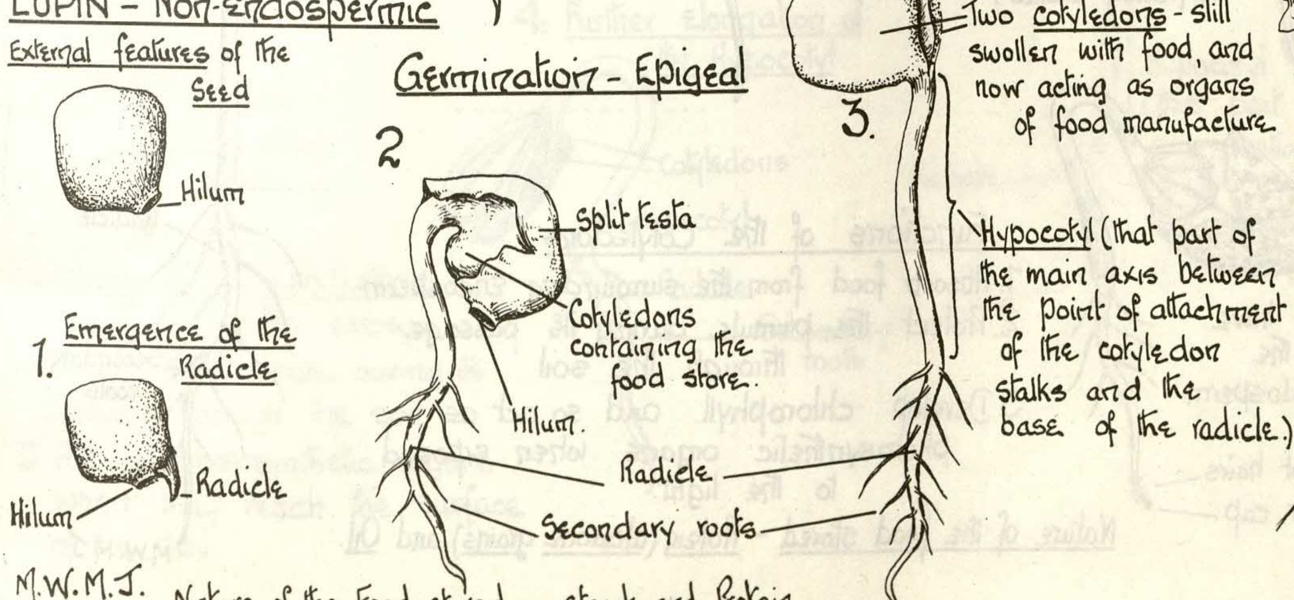


Germination - Hypogeal.





LUPIN - Non-endospermic



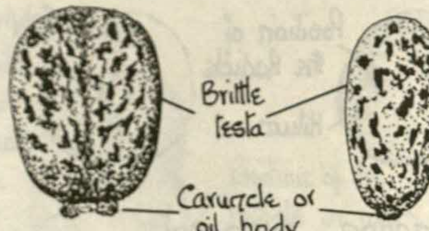
M.W.M.J.

Nature of the Food stored - starch and Protein.

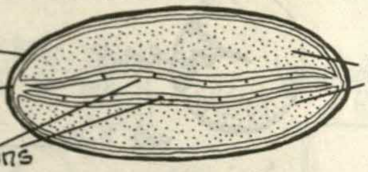
12. DICOTYLEDONS - SEED STRUCTURE - GERMINATION

Structure of CASTOR OIL - Endospermic (food stored outside the embryo)

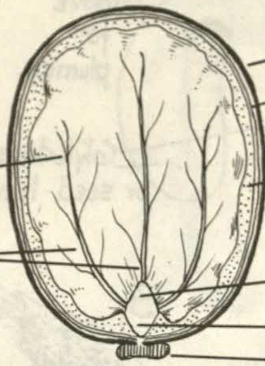
Front View   Side View.



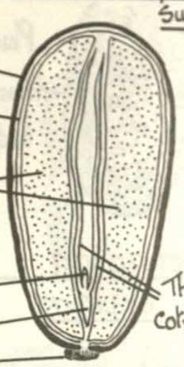
Transverse section



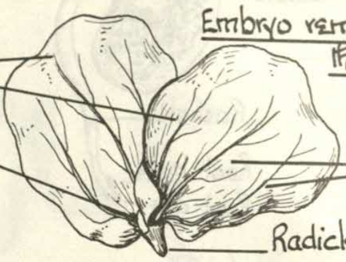
Longitudinal section parallel to the flattened surface.



Longitudinal section at rightangles to the flattened surface.



Embryo removed from the seed.

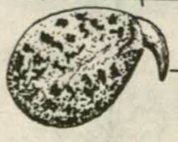


Germination of CASTOR OIL.

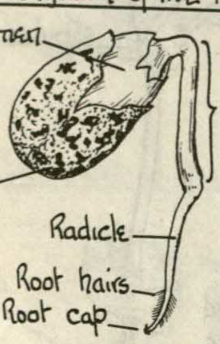
Epigeal (cotyledons coming above the surface of the ground)

The plumule is protected during its passage through the soil by the two cotyledons and the curvature of the hypocotyl

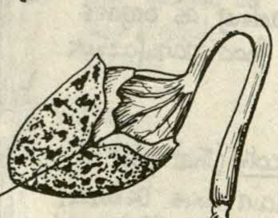
1. Emergence of the Radicle



2. Elongation of the Hypocotyl

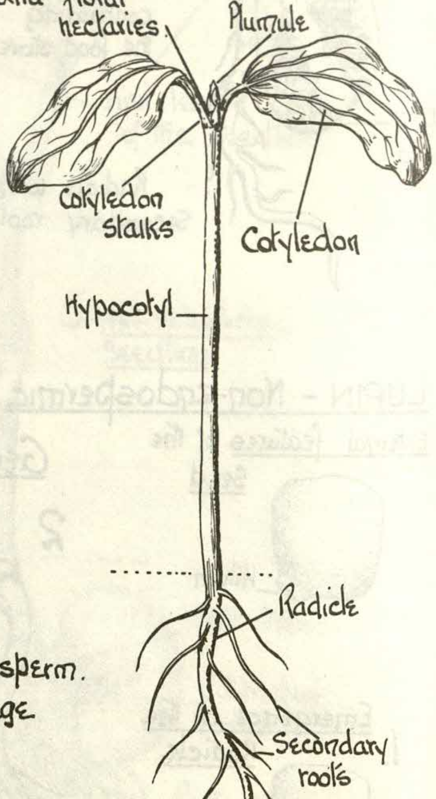


3. Further elongation of the Hypocotyl.



4. Liberation and withdrawal of the cotyledons

5. Liberation of the Plumule



Functions of the Cotyledons

1. Absorb food from the surrounding endosperm.
2. Protect the plumule during its passage through the soil
3. Develop chlorophyll and so act as photosynthetic organs when exposed to the light.

Nature of the food stored - Protein (aleurone grains) and Oil.

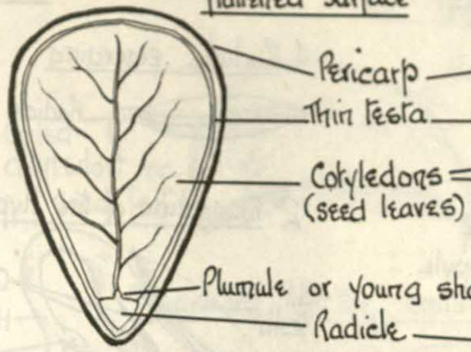
M.W. M.J.

DICOTYLEDONS - SEED STRUCTURE - GERMINATION

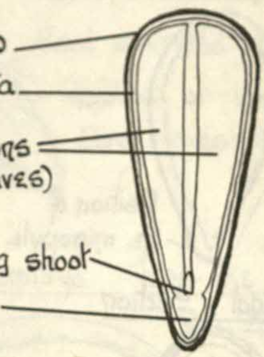
Structure of SUNFLOWER - Non-endospermic (food stored within the cotyledons)

Front View. Side View

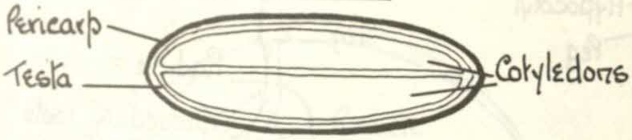
Longitudinal Section parallel to the flattened surface



Longitudinal section at rightangles to the flattened surface.



Transverse Section

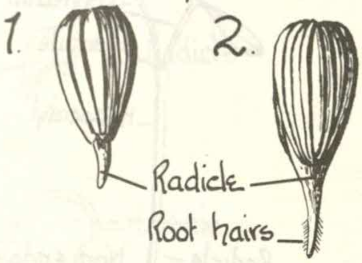


Chemical nature of the food stored - Protein and Oil.

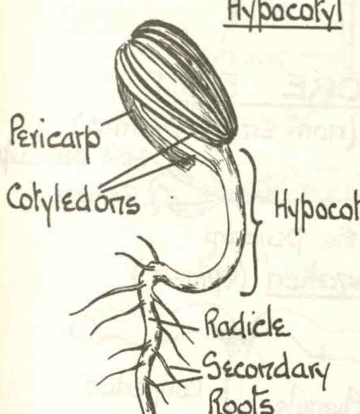
Germination of SUNFLOWER

Epigeal (cotyledons coming above the surface of the ground)
The plumule is protected during its passage through the soil by the two cotyledons and the curvature of the hypocotyl.

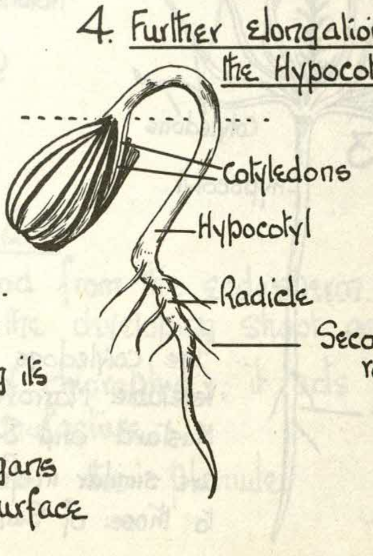
Emergence of the Radicle



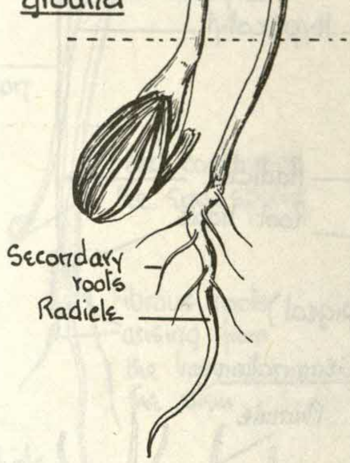
3. Elongation of the Hypocotyl



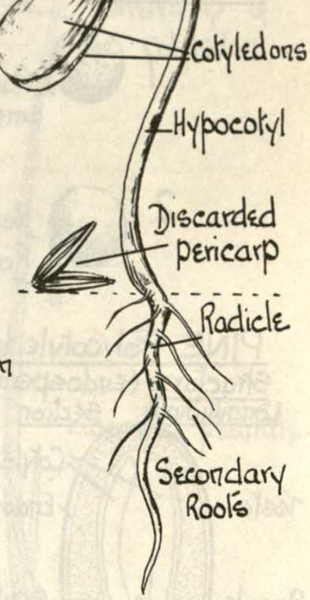
4. Further elongation of the Hypocotyl.



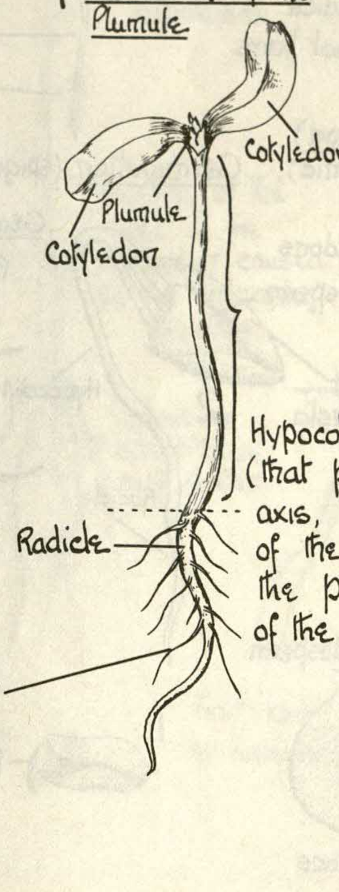
5. Hypocotyl appearing as a loop above the ground



6. Liberation of the cotyledons from the pericarp



7. Liberation of the Plumule.



Hypocotyl (that part of the main axis, between the base of the radicle, and the point of attachment of the cotyledon stalks.)

Functions of the Cotyledons.

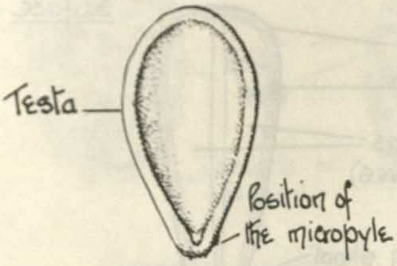
1. Store food for the embryo
2. Protect the plumule during its passage through the soil
3. Act as photosynthetic organs when they reach the surface of the soil.

M.W.M.J.

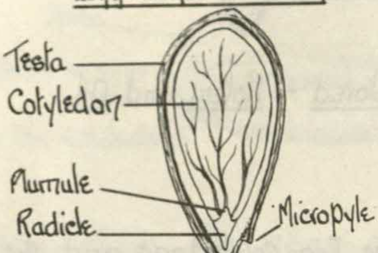
SEED STRUCTURE - GERMINATION

VEGETABLE MARROW - Structure (non-endospermic); Germination (epigeal)

Seed - External Features

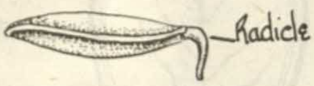


Longitudinal Section

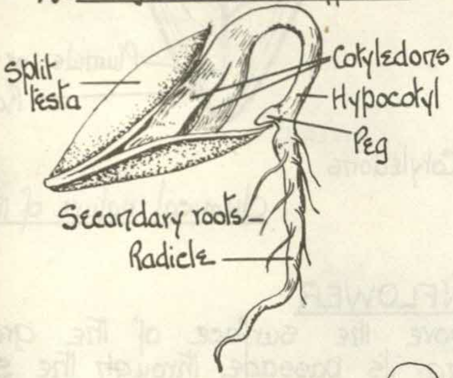


Germination

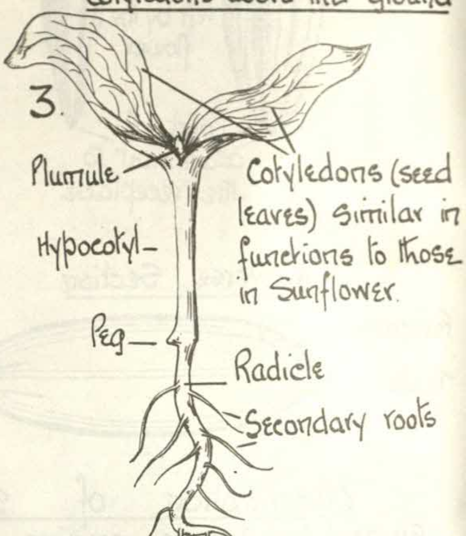
1. Radicle emerging



2. Elongation of the Hypocotyl

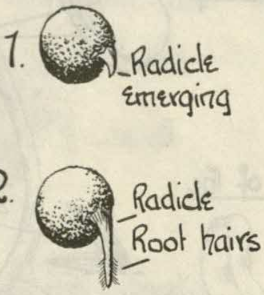


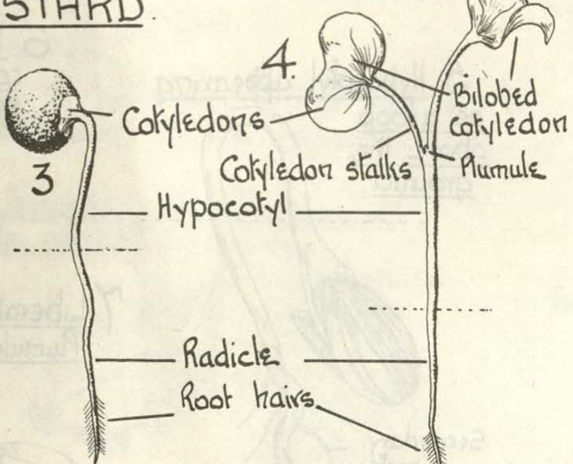
Cotyledons above the ground



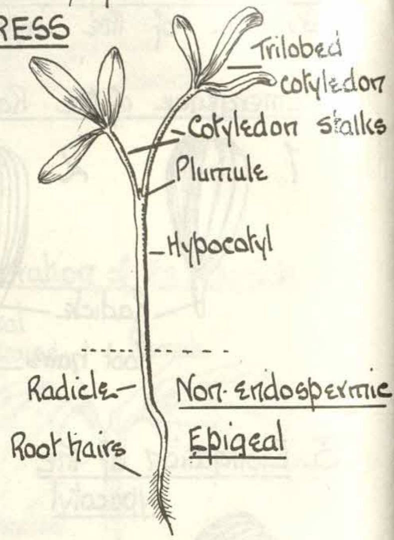
MUSTARD

Structure (non-endospermic)
Germination (epigeal)





CRESS

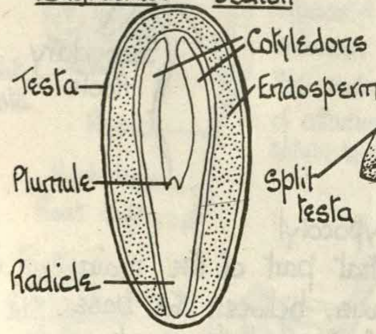


Non-endospermic
Epigeal

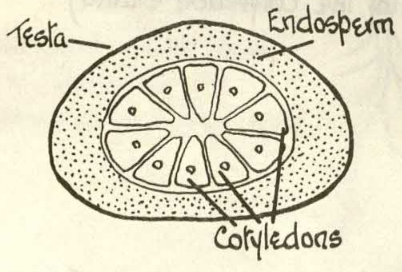
PINE (Polycotyledon)

Structure (endospermic); Germination (epigeal)

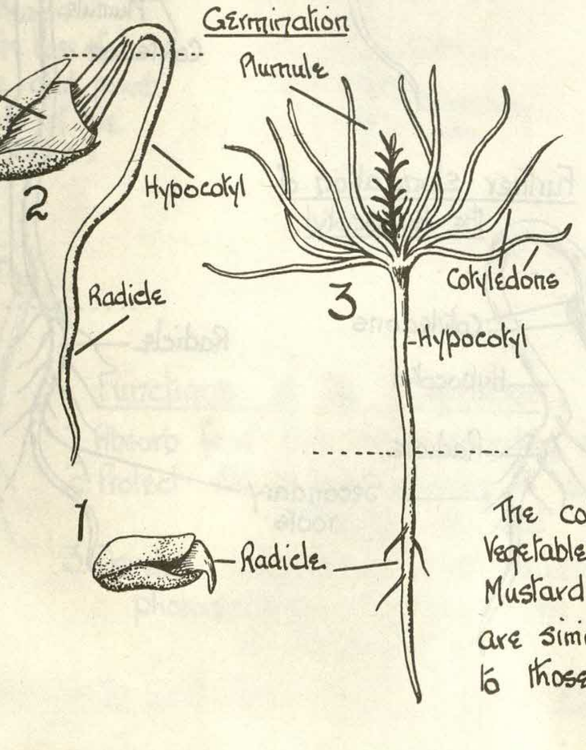
Longitudinal Section



Transverse Section



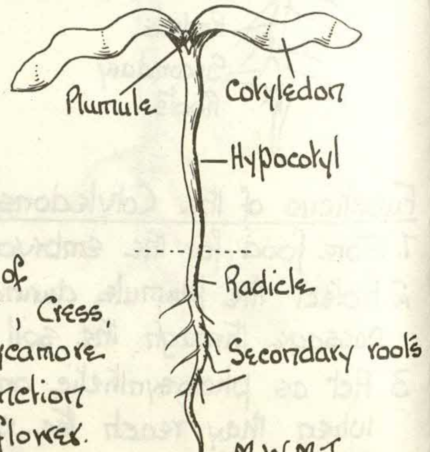
Germination



SYCAMORE FRUIT

Seed (non-endospermic)

Germination (epigeal)



The cotyledons of Vegetable Marrow, Cress, Mustard and Sycamore are similar in function to those of Sunflower.

M.W.M.J.

Structure of ONION - Endospermic (food stored outside the embryo)

External features

Longitudinal section of the seed from the edge to the opposite face.

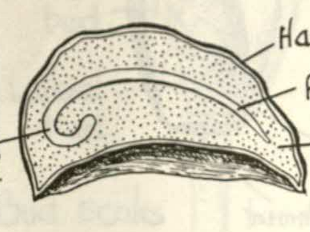


Diagram of the Embryo

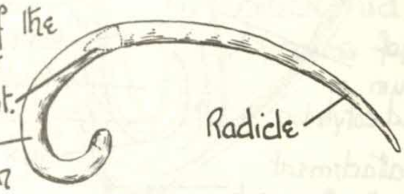
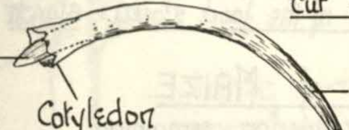


Diagram of the embryo. Tube-like cotyledon cut away.



Germination of ONION

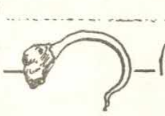
DATE PALM (also endospermic and Epigeal)

Epigeal (the cotyledon coming above the ground)
The plumule is protected during its passage through the soil by the tube-like cotyledon.

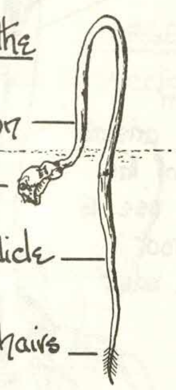
Emergence of the Radicle.

1.

2

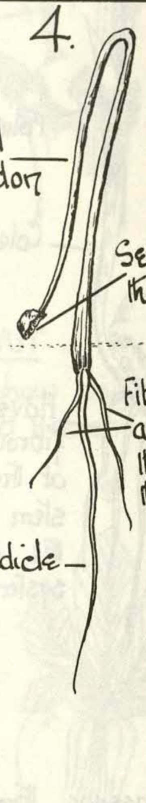


3. Elongation of the Cotyledon.

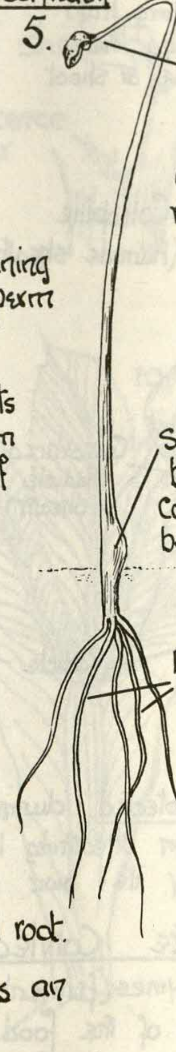


Further elongation of the Cotyledon

4.

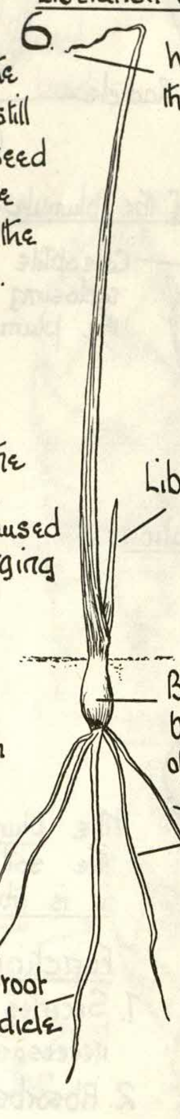


5.



Liberation of the plumule.

6.



Functions of the Cotyledon.

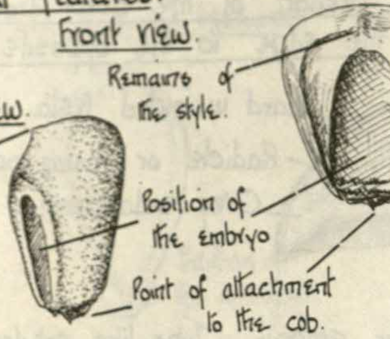
1. The tip absorbs the food from the endosperm and passes it on to the developing shoot and root.
2. Being green (presence of chlorophyll), it acts as an organ of food manufacture.
3. It protects and liberates the plumule.

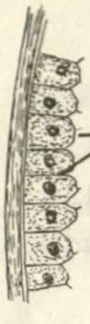
M.W.M.J.

MONOCOTYLEDONS - SEED STRUCTURE - GERMINATION

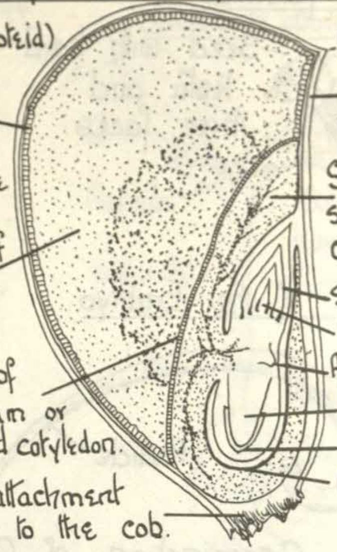
Structure of MAIZE Endospermic (food stored outside the embryo)

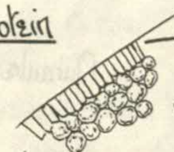
External features.





Longitudinal section of the fruit at rightangles to the flattened surface.

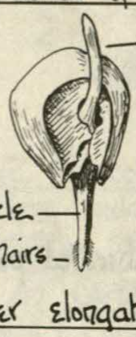


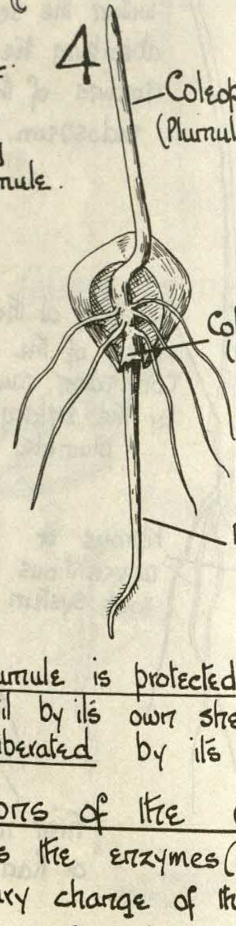


Chemical nature of the food stored - starch and Protein

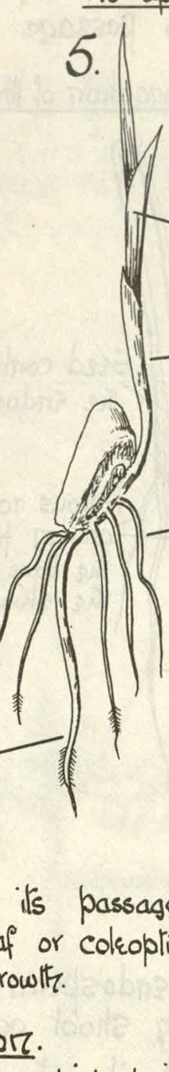
Germination of MAIZE.

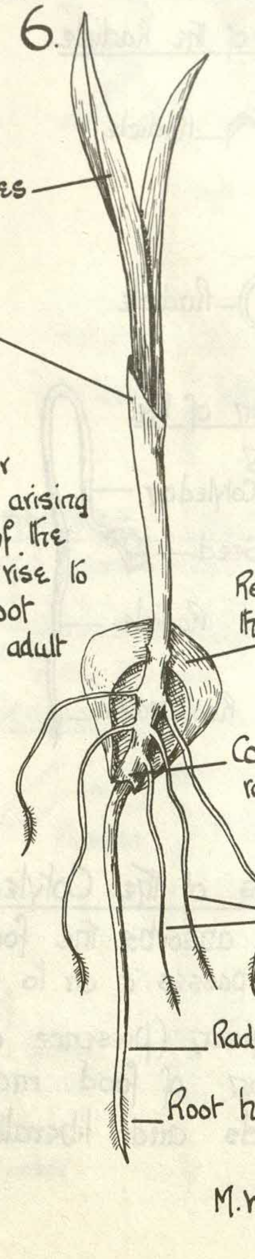
Hypogeal (the cotyledon remaining beneath the surface of the ground)





The appearance of the first foliage leaves of the plumule.





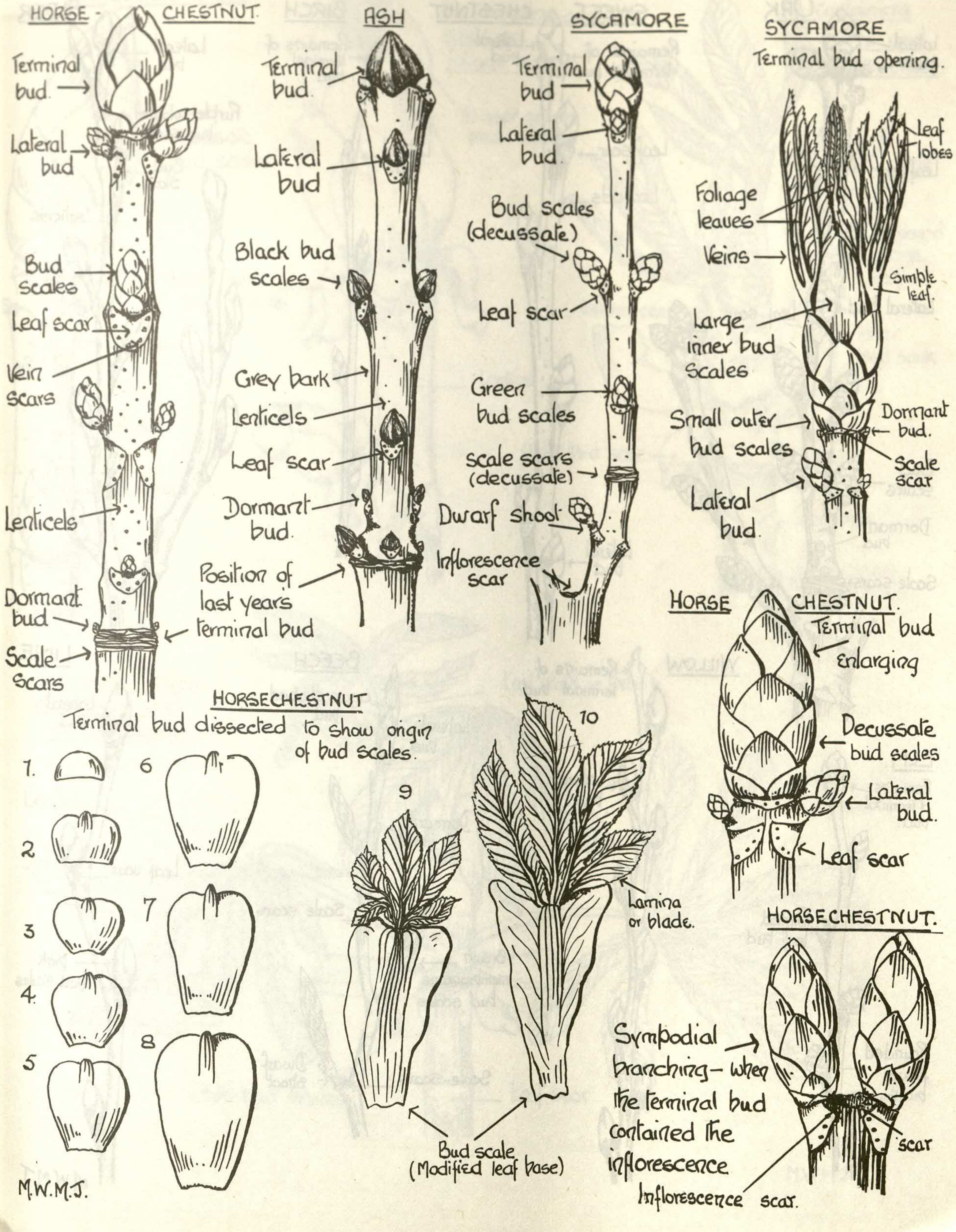
The plumule is protected during its passage through the soil by its own sheathing leaf or coleoptile, while it is liberated by its own growth.

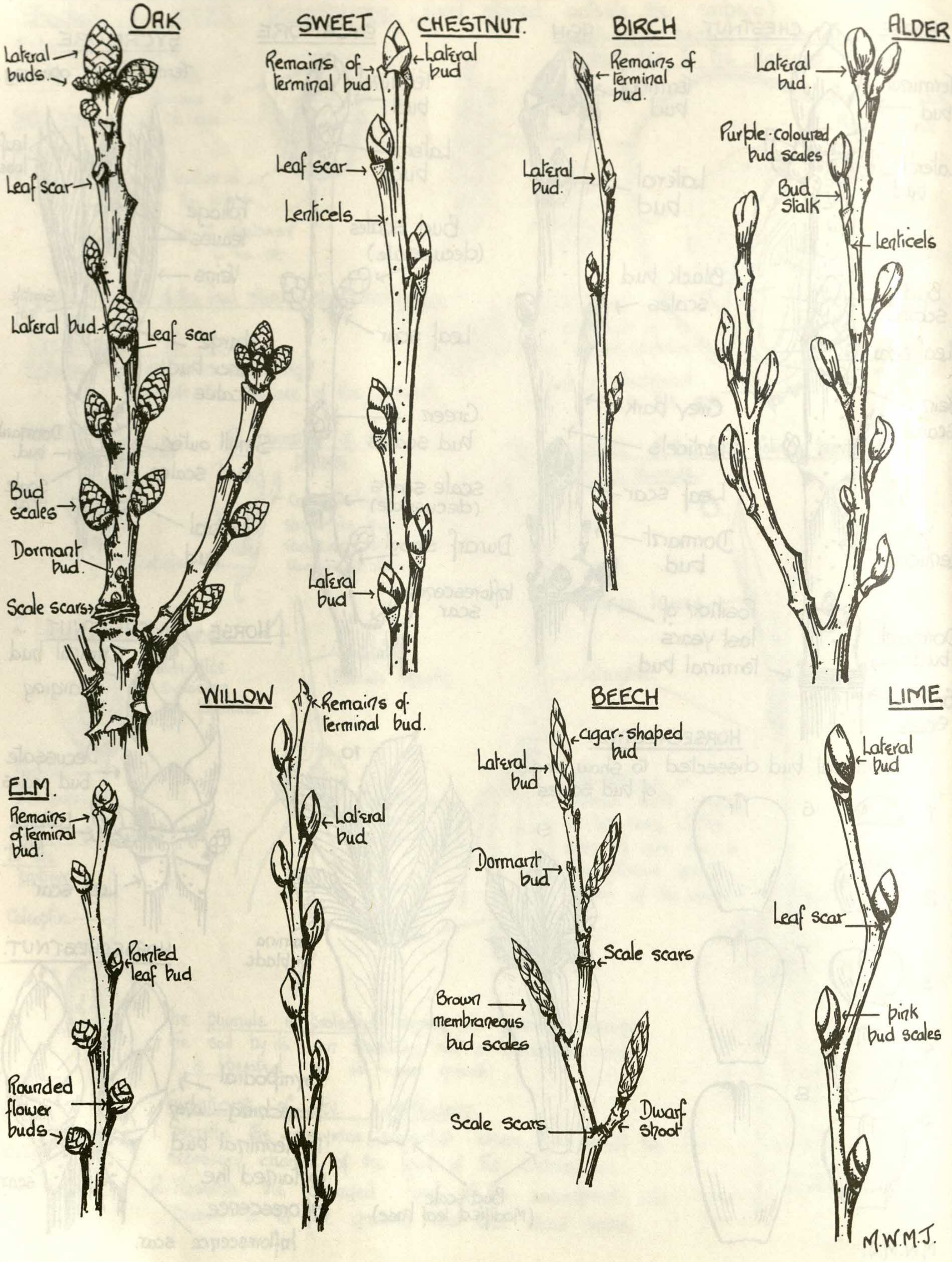
Functions of the Cotyledon.

1. Secretes the enzymes (ferments) which bring about the necessary change of the food of the endosperm.
2. Absorbs the changed food of the endosperm and passes it to the growing root and shoot system.

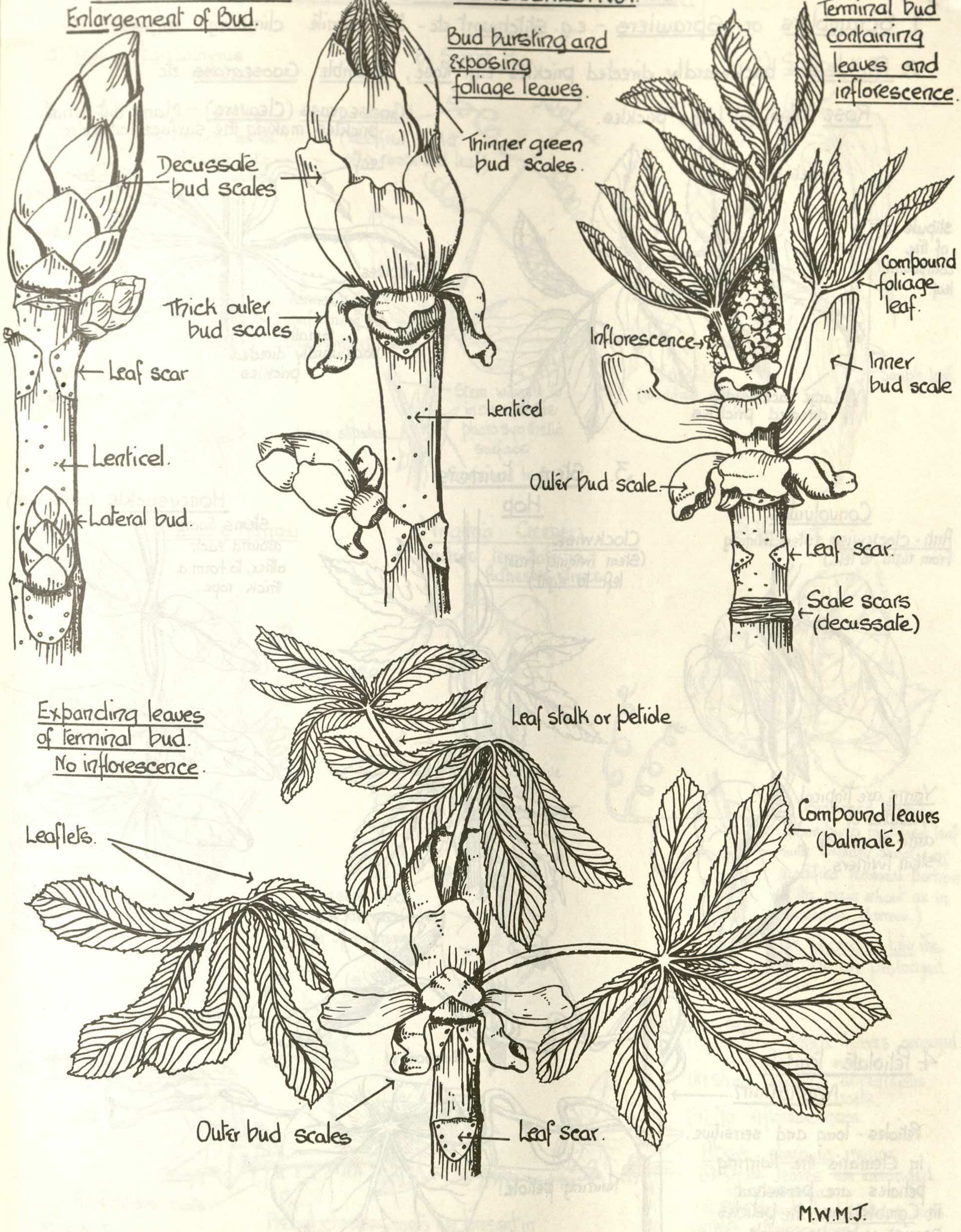
M.W.M.J.

BUDS AND BRANCHES - MONOPODIA.




OAK
Lateral buds.
Leaf scar
Lateral bud
Leaf scar
Bud scales
Dormant bud.
Scale scars
SWEET CHESTNUT.
Remains of terminal bud.
Lateral bud
Leaf scar
Lenticels
Lateral bud
BIRCH
Remains of terminal bud.
Lateral bud.
ALDER
Lateral bud.
Purple-coloured bud scales
Bud stalk
Lenticels
ELM.
Remains of terminal bud.
Pointed leaf bud
Rounded flower buds
WILLOW
Remains of terminal bud.
Lateral bud
BEECH
Cigar-shaped bud
Lateral bud
Dormant bud
Scale scars
Brown membraneous bud scales
Scale scars
Dwarf shoot
LIME
Lateral bud
Leaf scar
pink bud scales
M.W.M.J.

OPENING BUDS OF HORSECHESTNUT.

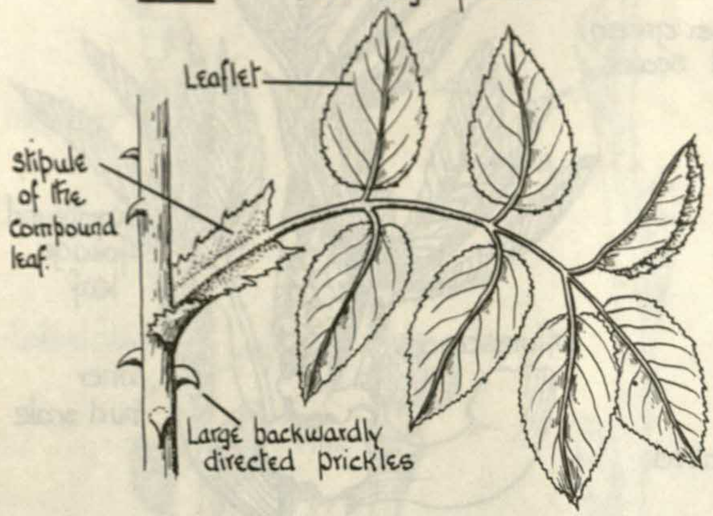


CLIMBING PLANTS

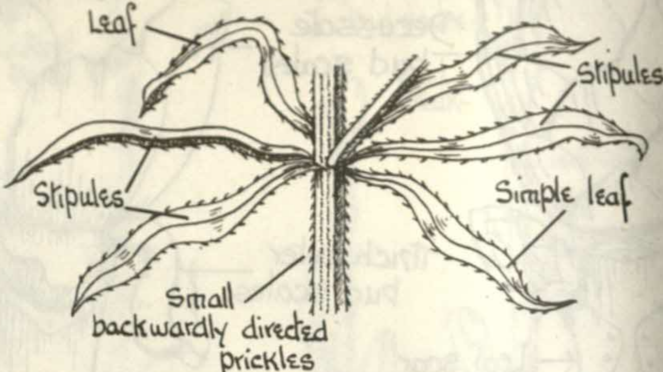
1. Scramblers or Sprawlers - e.g. Stitchwort etc - No definite climbing organs.

2. Prickles - backwardly directed prickles - e.g. Rose, Bramble, Goosegrass etc.

Rose - Few, but large prickles.



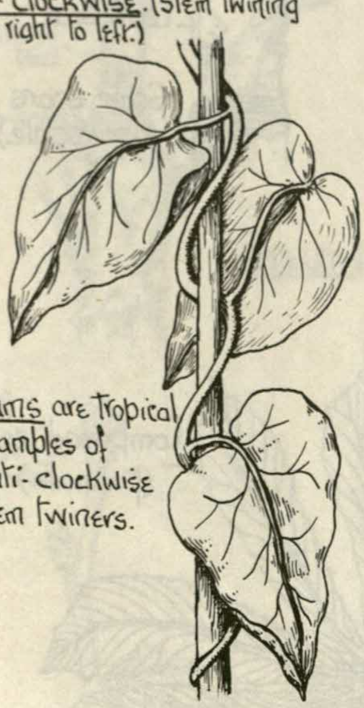
Goosegrass (Cleavers) - Many, but small prickles, making the surface adhesive.



3. Stem twiners

Convolvulus

Anti-clockwise. (stem twining from right to left.)



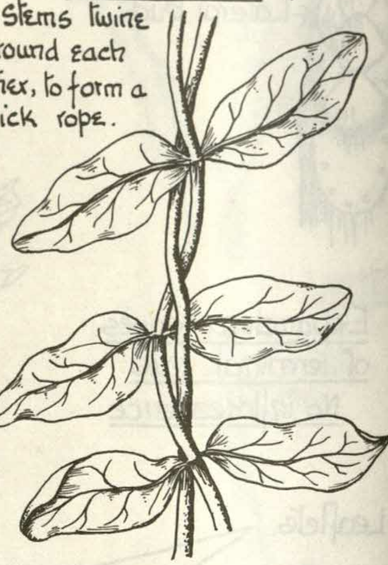
Yams are tropical examples of anti-clockwise stem twiners.

Hop

Clockwise. (Stem twining from left to right.)

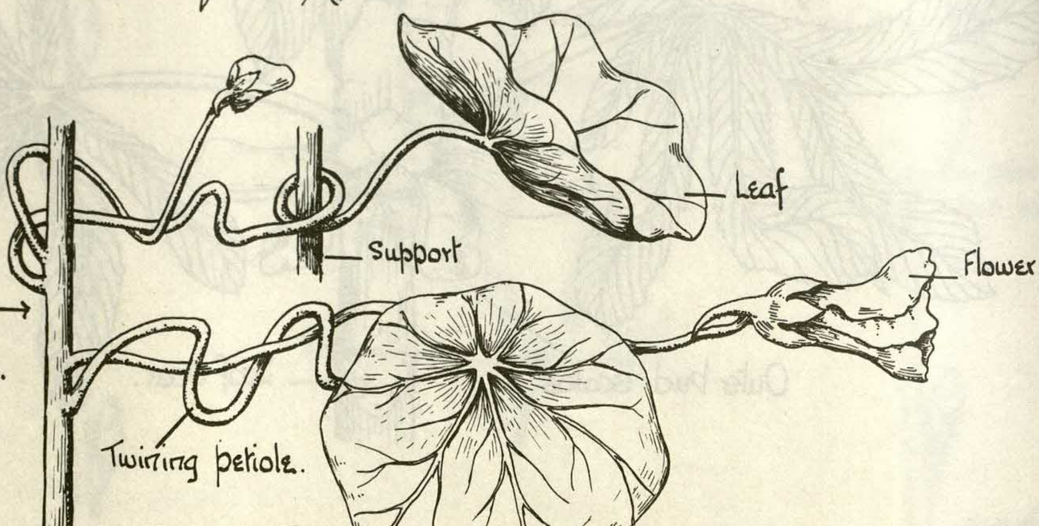
Honeysuckle (clockwise)

Stems twine around each other, to form a thick rope.



4. Petiolate tendrils

Nasturtium.



Petioles - long and sensitive.

In Clematis the twining petioles are persistent

In Combretium, the petioles persist as hooks which enable the plant to climb.

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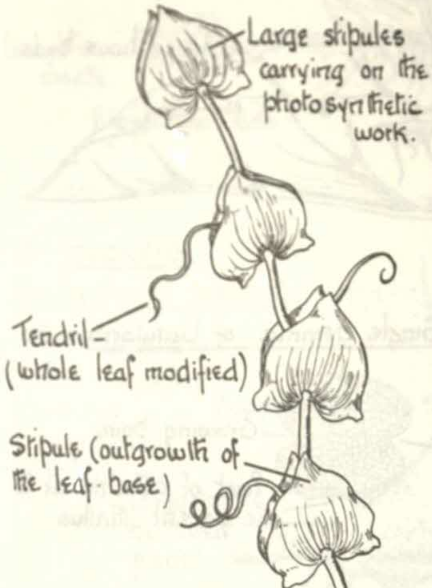
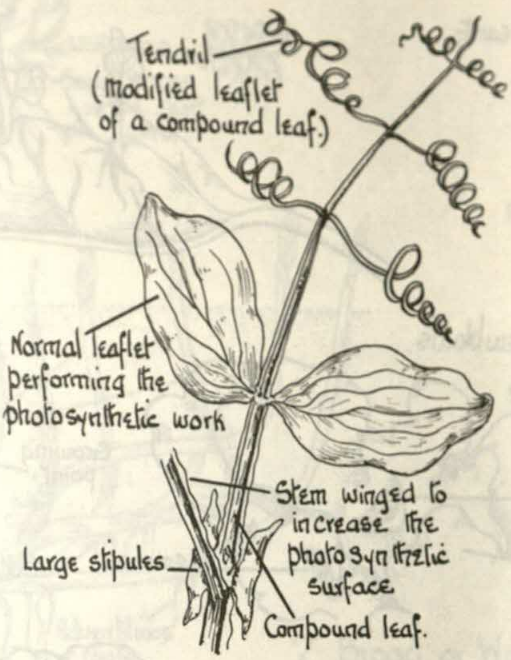
CLIMBING PLANTS (continued)

5. Tendrils

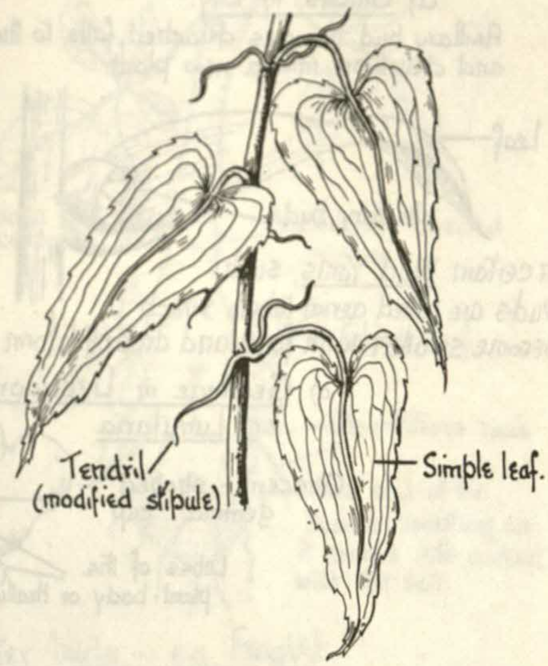
a) Yellow Pea (Lathyrus Aphaca)



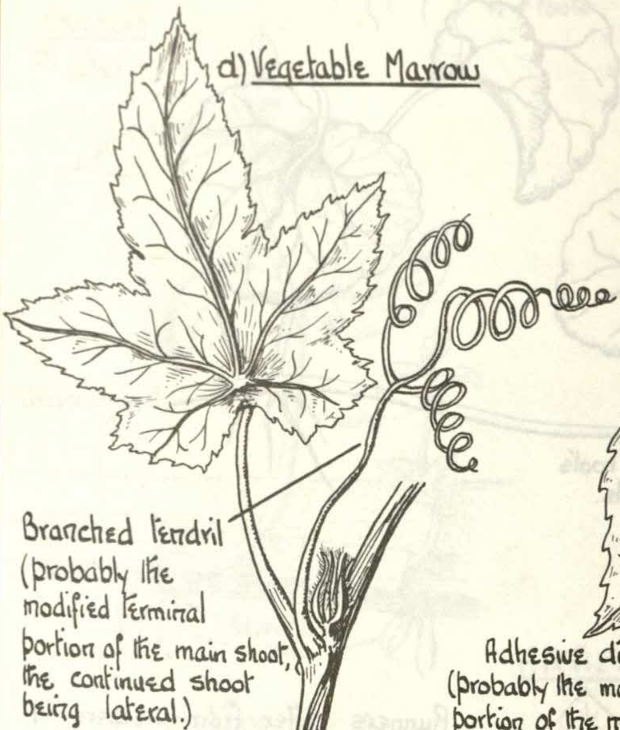
b) Sweet Pea.



c) Smilax × 2



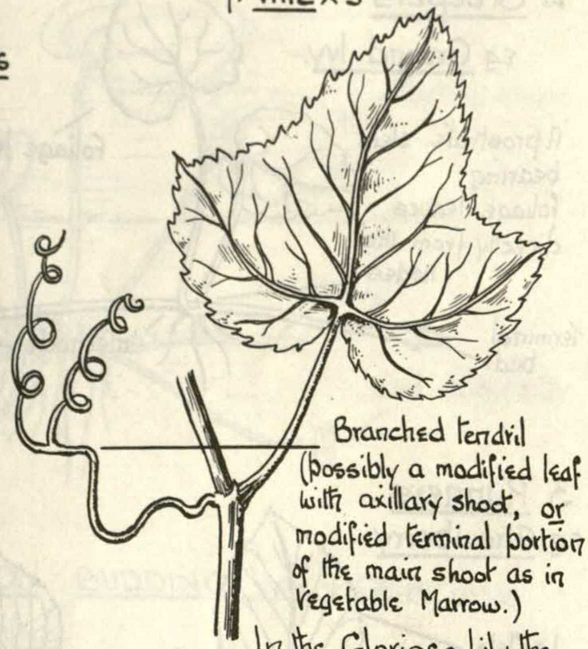
d) Vegetable Marrow



e) Virginia Creeper.

Tendrils terminate in Adhesive discs

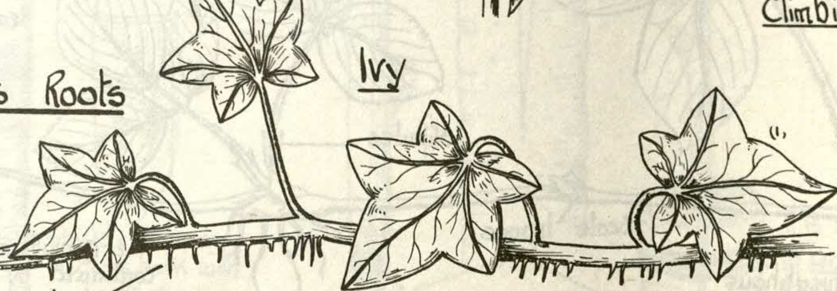
f) Vine × $\frac{1}{3}$



In the Gloriosa Lily the leaf blade tips are prolonged into tendrils.

6. Adventitious Roots

Ivy



Climbing region.
(i) Palmately lobed leaves arranged in a leaf mosaic.
(ii) Stems bearing adventitious roots.
(iii) No inflorescences.

Above climbing region.
(i) Ovate leaves not arranged in a mosaic.
(ii) Stem devoid of adventitious roots.
(iii) With inflorescences.

Aerial clasping roots are present in Fig and Black Pepper.

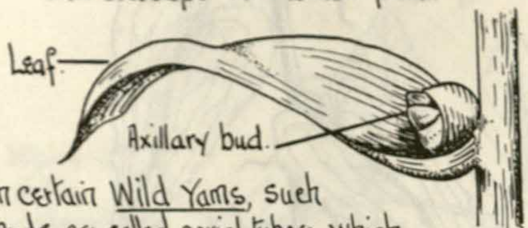
M.W.M.J.

VEGETATIVE REPRODUCTION OR PROPAGATION

1. Bulbils and Gemmae.

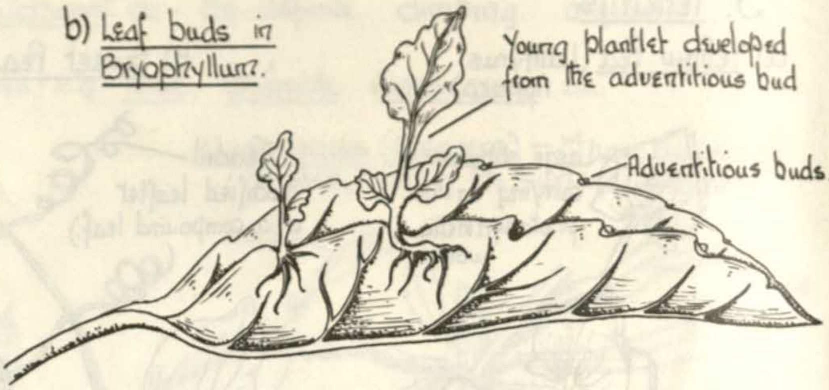
a) Bulbils in Lily.

Axillary bud becomes detached, falls to the earth, and develops into a new plant.



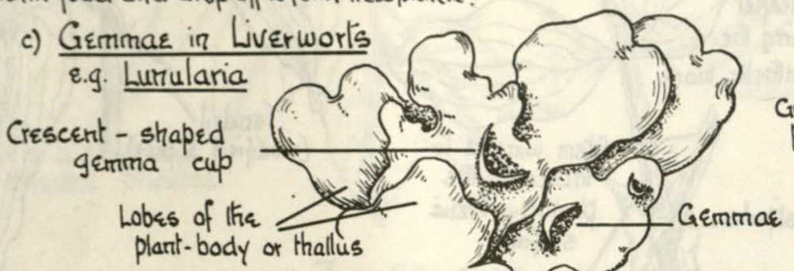
In certain Wild Yams, such buds are called aerial tubers which become swollen with food and drop off to form new plants.

b) Leaf buds in Bryophyllum.

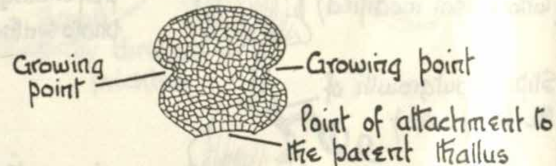


c) Gemmae in Liverworts

e.g. Lunularia

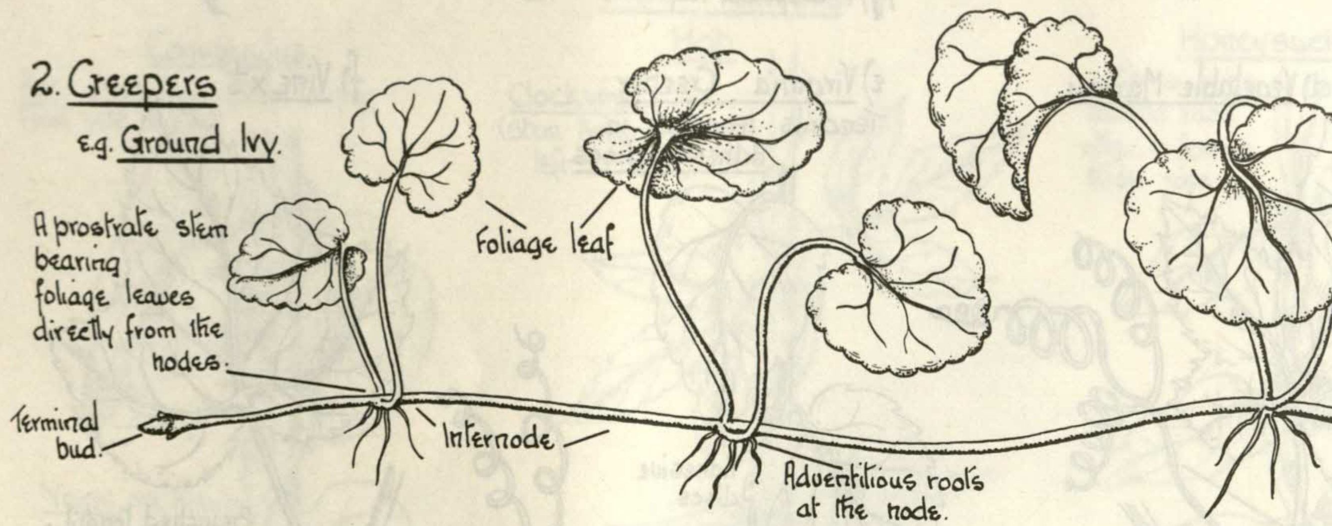


Single gemma of Lunularia x 30



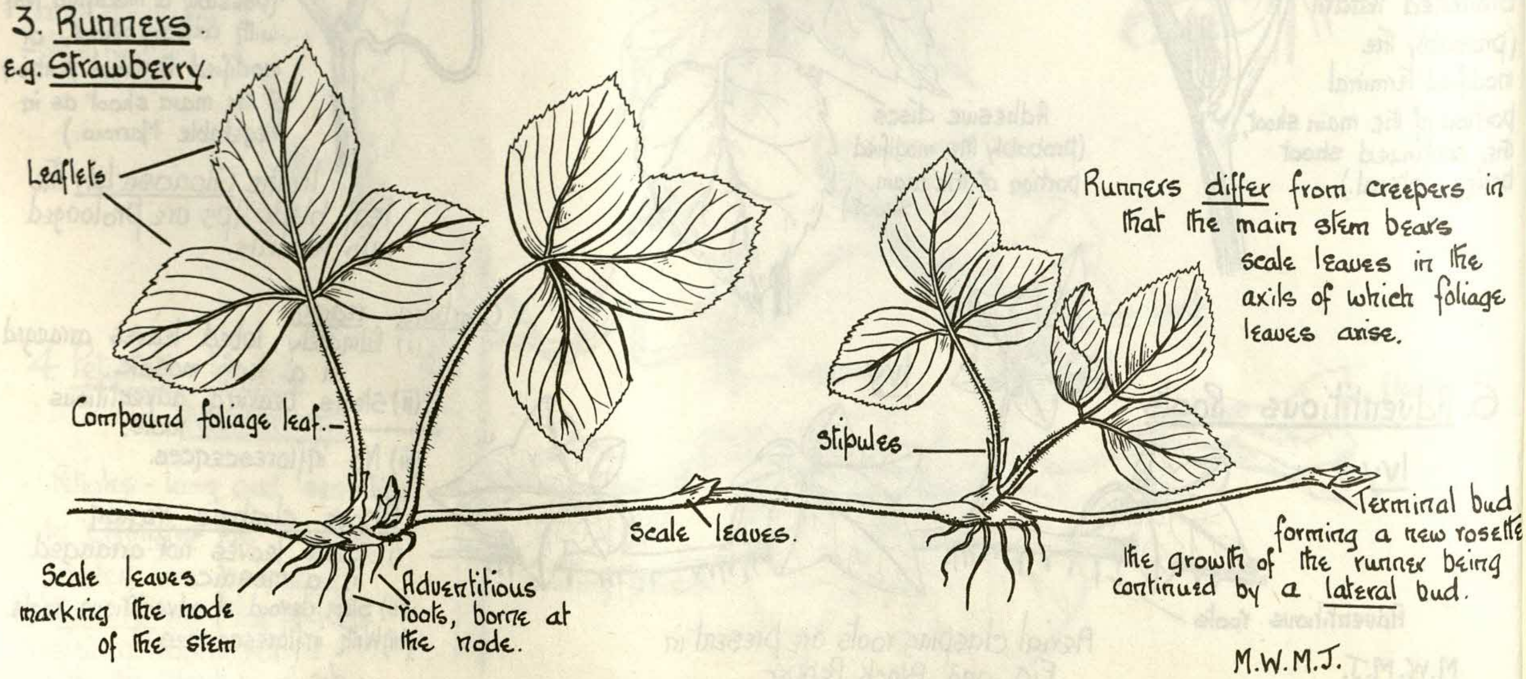
2. Creepers

e.g. Ground Ivy.



3. Runners.

e.g. Strawberry.



Runners differ from creepers in that the main stem bears scale leaves in the axils of which foliage leaves arise.

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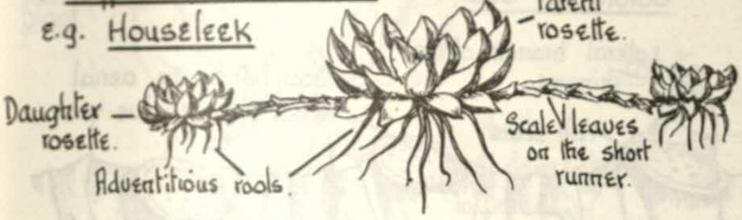
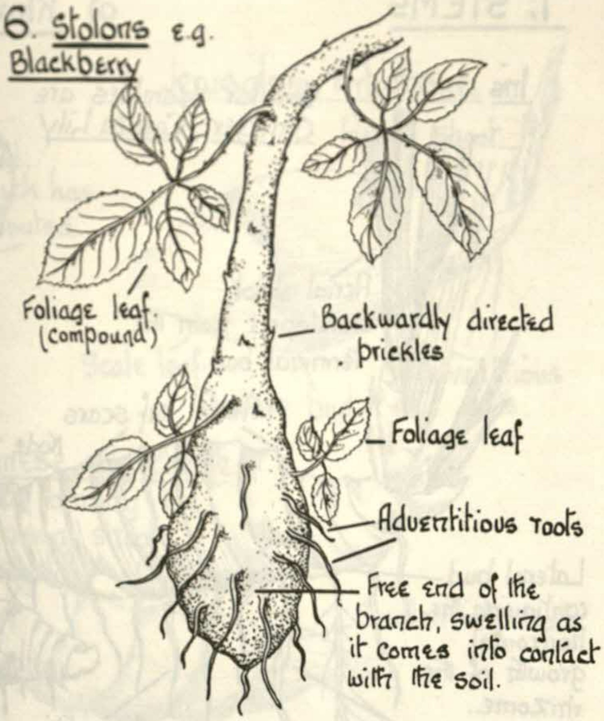
VEGETATIVE REPRODUCTION (continued)

4. Offsets (short runner.)
e.g. Houseleek



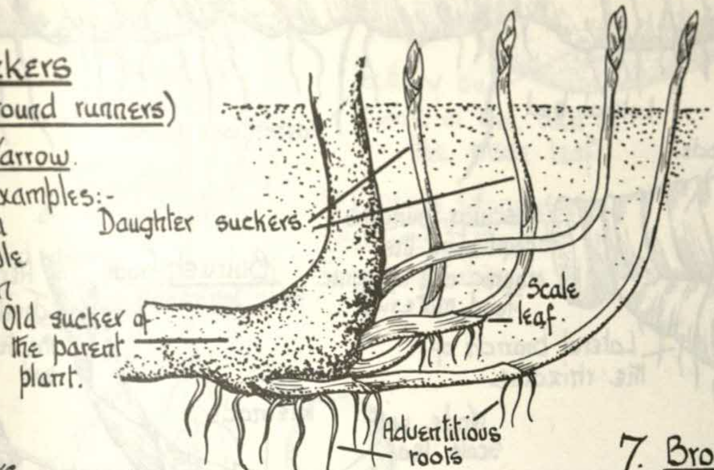
6. Stolons e.g. Blackberry



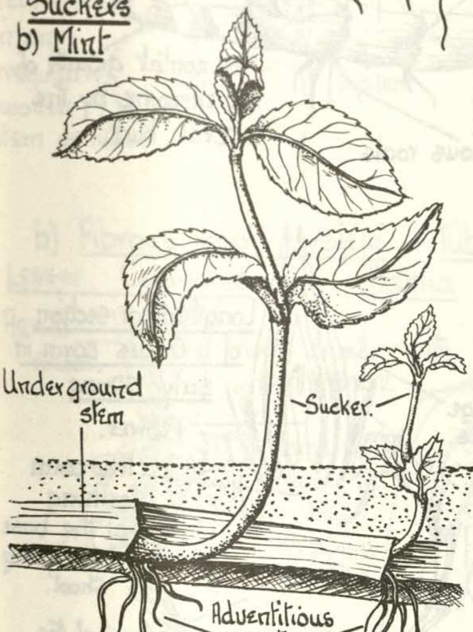
5. Suckers
(Underground runners)

e.g. Yarrow.

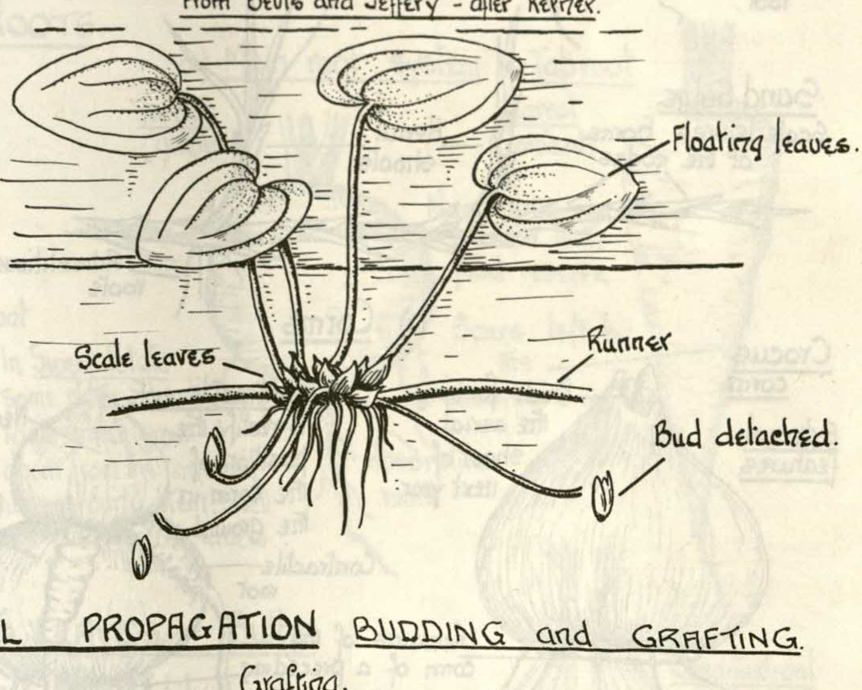
Other examples:-
Banana
Pineapple
Plantain



Suckers
b) Mint

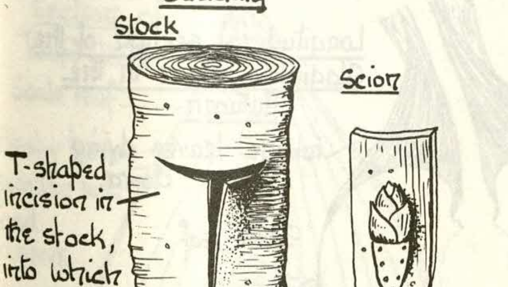


7. Brood or Winter buds - e.g. Frogbit
From Bevis and Jeffery - after Kerner.



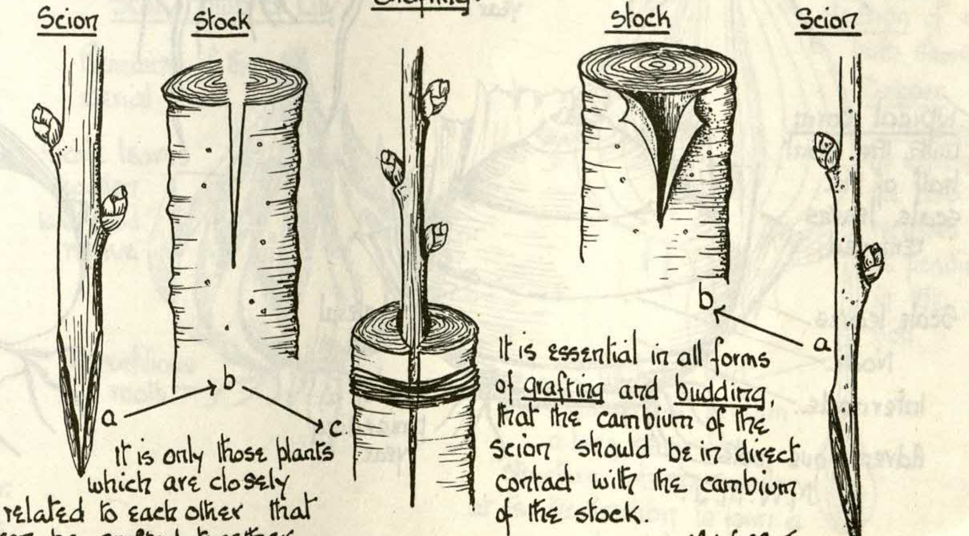
ARTIFICIAL PROPAGATION BUDDING and GRAFTING.

Budding



Budding is particularly practiced in rose, peach and plum cultivation

Grafting.



It is only those plants which are closely related to each other that can be grafted together.

It is essential in all forms of grafting and budding, that the cambium of the scion should be in direct contact with the cambium of the stock.

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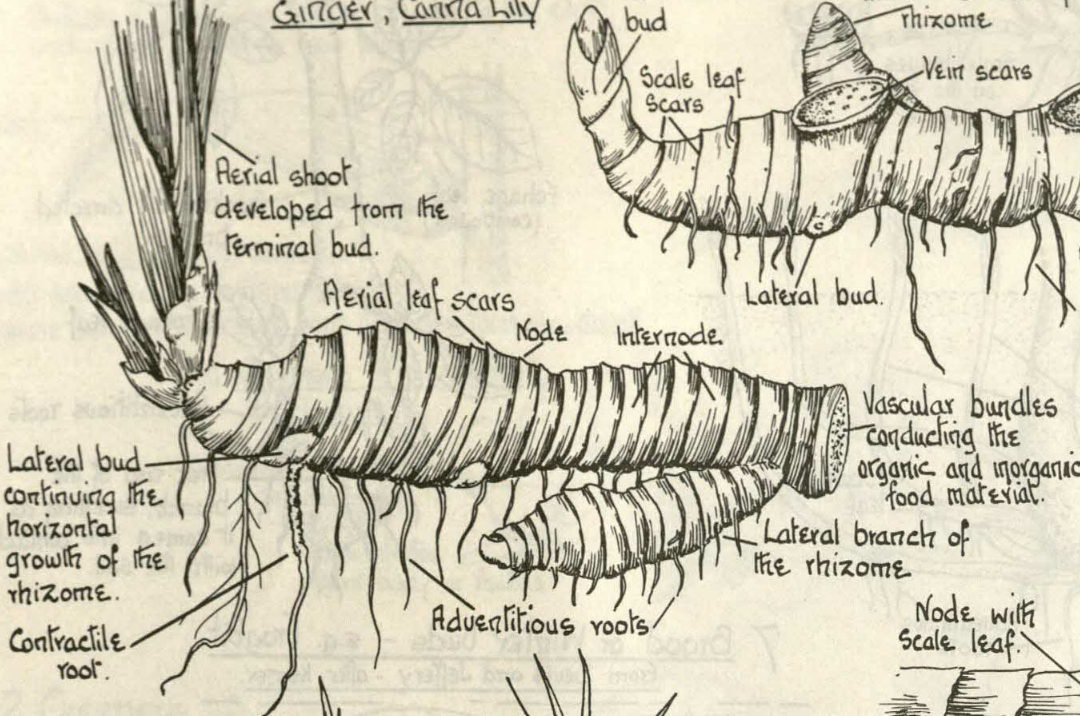
STORAGE OF FOOD MATERIAL

1. STEMS

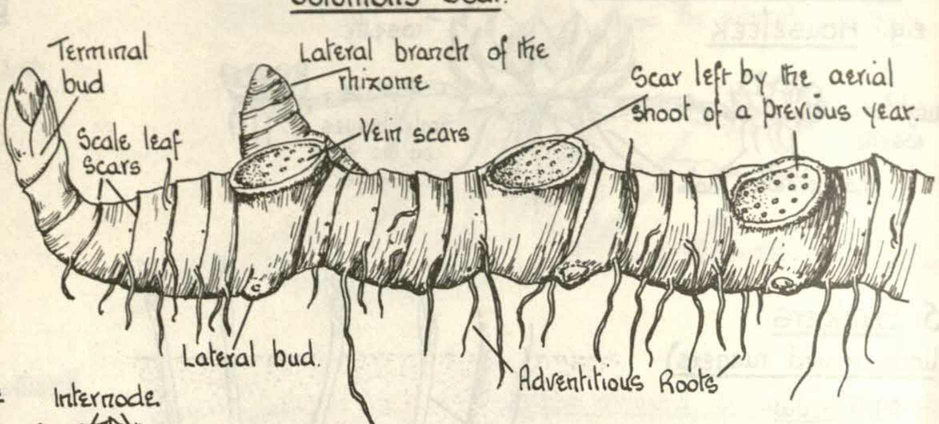
a) Rhizomes

Iris

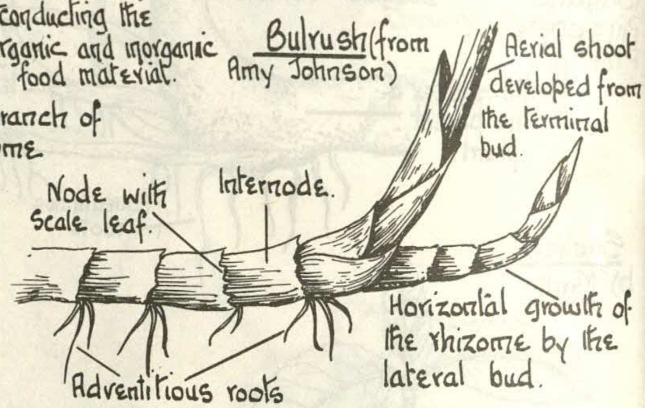
Similar examples are Ginger, Canna Lily



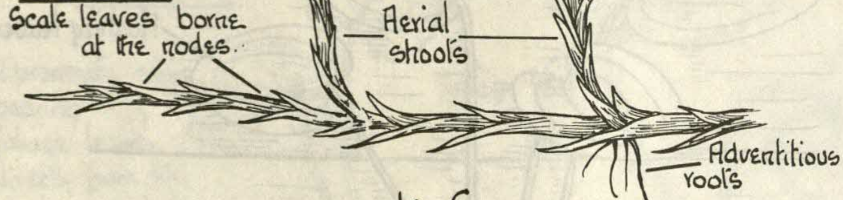
Solomon's Seal.



Bulrush (from Amy Johnson)



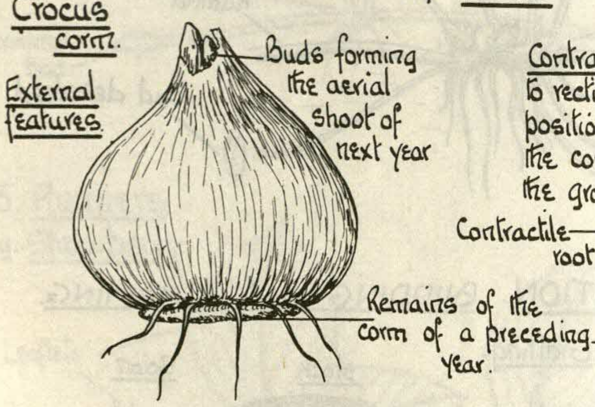
Sand Sedge

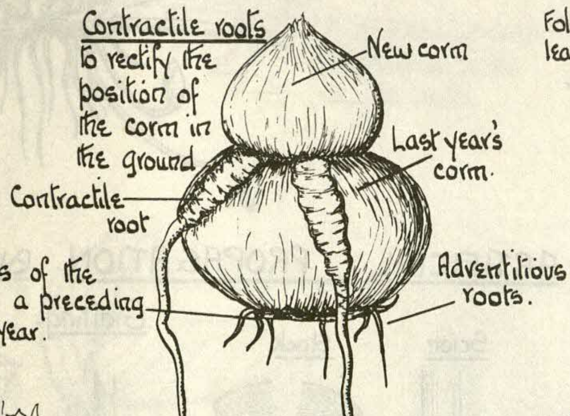


b) Corms

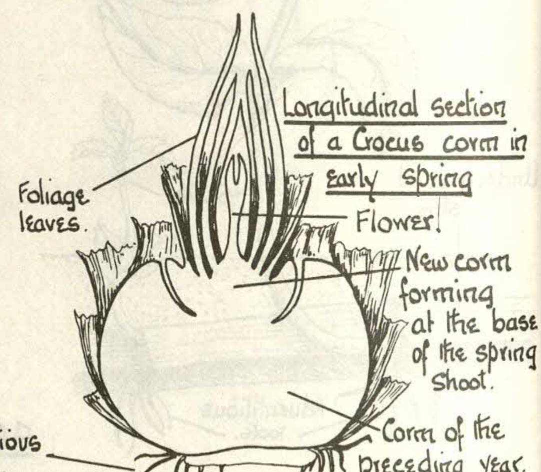
Crocus corm.

External features.

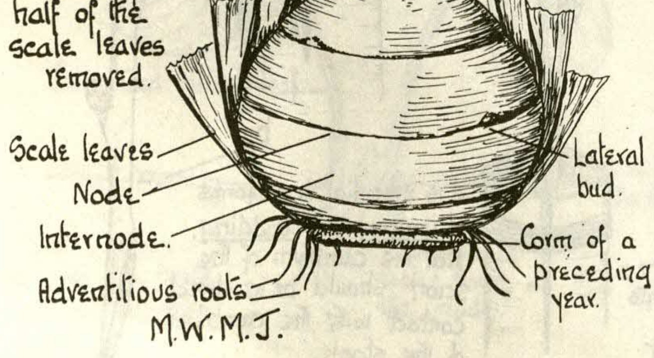




Longitudinal section of a Crocus corm in early spring



Typical corm with the front half of the scale leaves removed.



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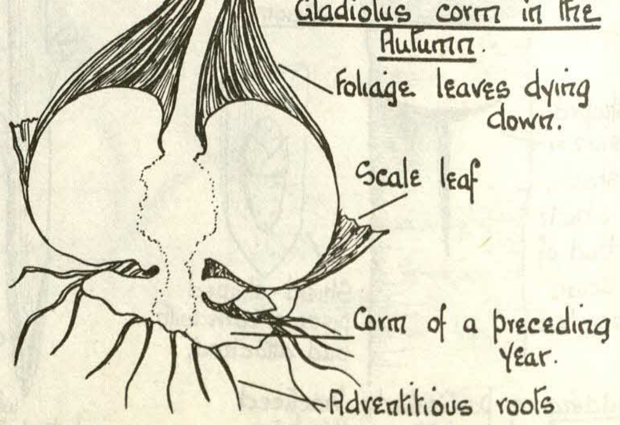
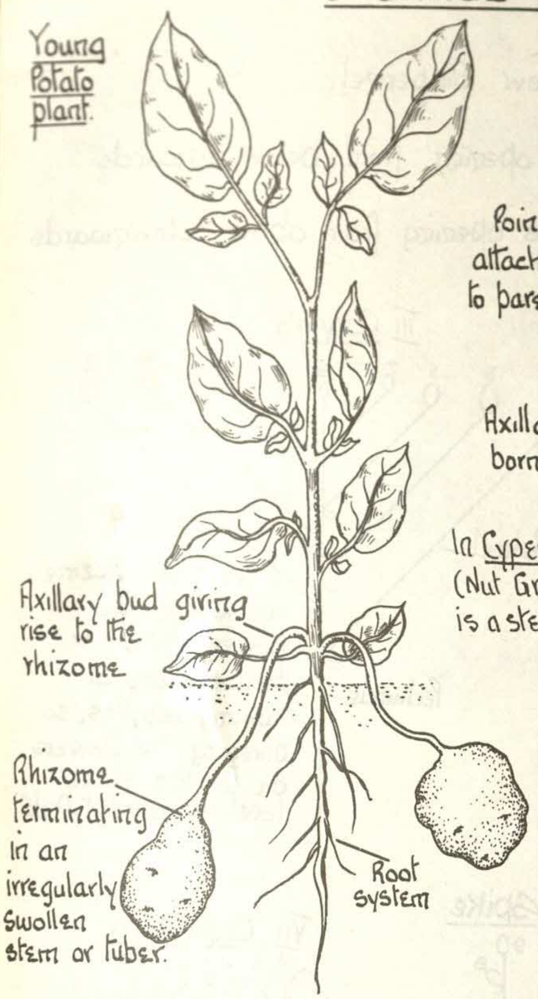
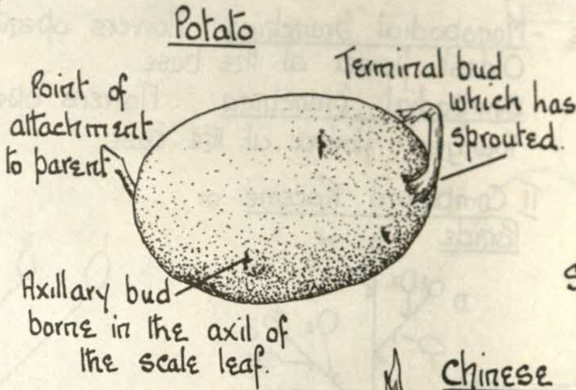
Longitudinal section of the Gladiolus corm in the Autumn.



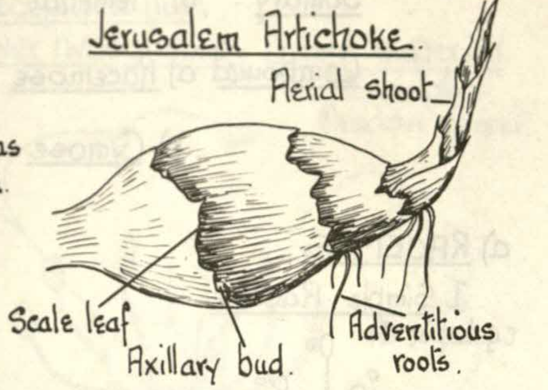
STORAGE OF FOOD MATERIAL (continued)

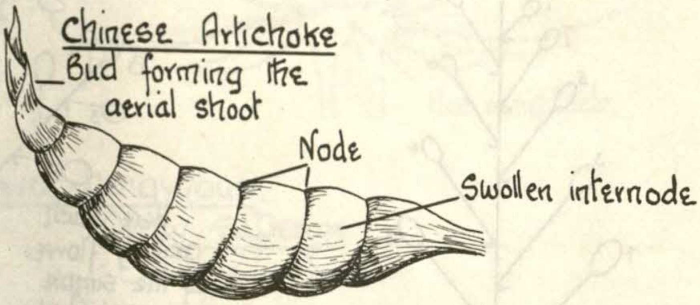
STEMS c) Tubers.





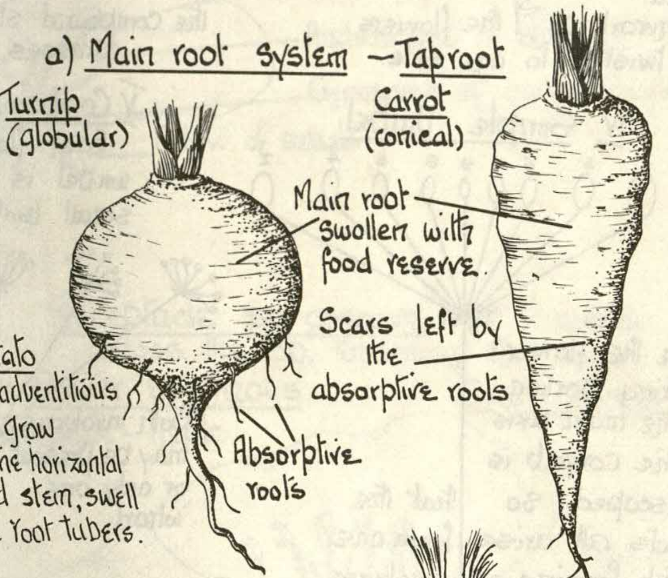
In Cyperus rotundus (Nut Grass), the "nut" is a stem tuber.



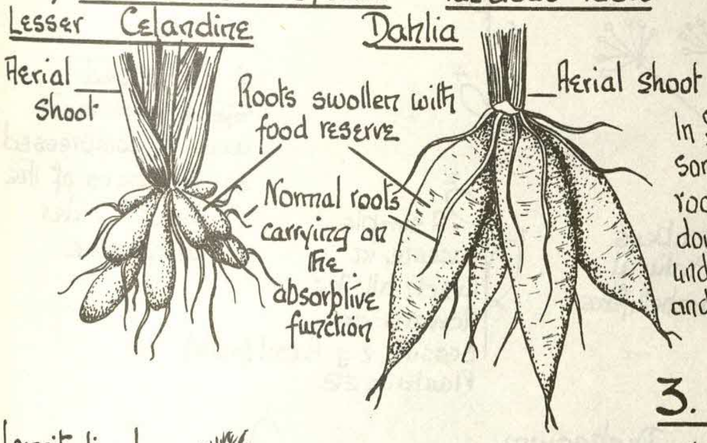


2. ROOTS.

a) Main root system – Taproot

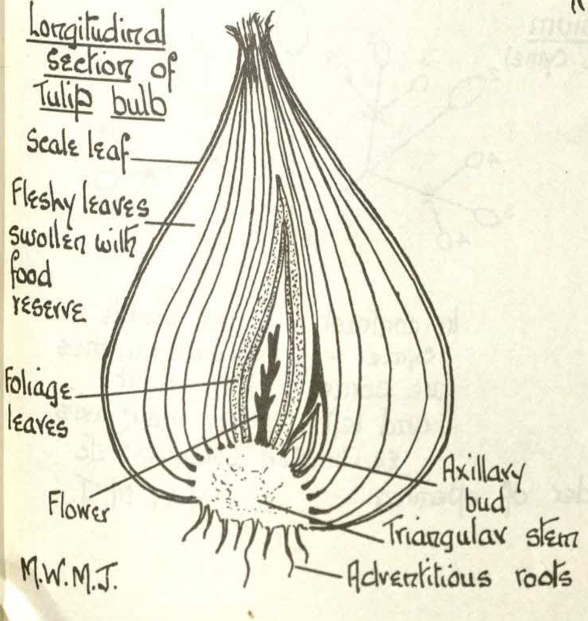


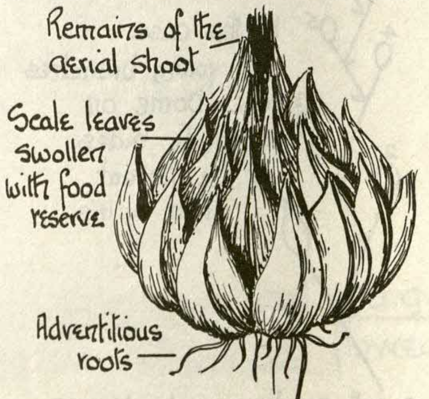
b) Fibrous root system – Tuberous roots

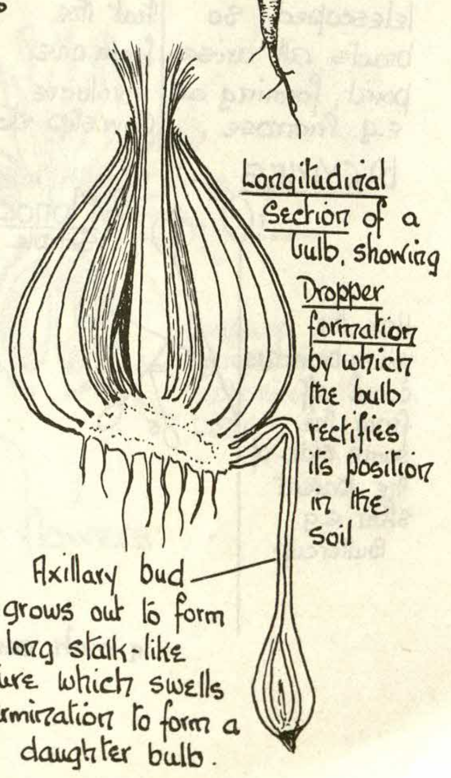


In Sweet Potato some of the adventitious roots which grow down from the horizontal underground stem, swell and produce root tubers.

3. LEAVES – Bulbs.







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FLOWER STRUCTURE. a) INFLORESCENCE.

Inflorescence. Arrangement of the flowers upon the stem.

Solitary. a) Terminal e.g. Tulip. b) Axillary e.g. Yellow Pimpernel.

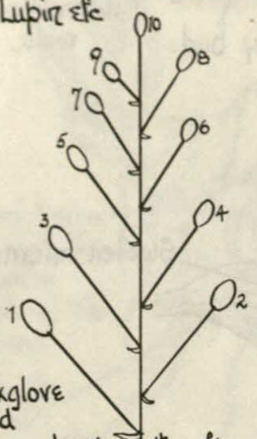
Compound a) Racemose - Monopodial branching; Flowers opening from below, upwards. Oldest flower at the base.

b) Cymose - Sympodial branching; Flowers opening from above, downwards. Youngest flower at the base.

a) RACEMES

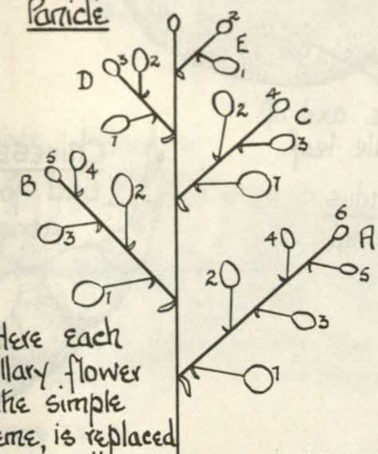
I Simple Raceme.

e.g. Lupin etc



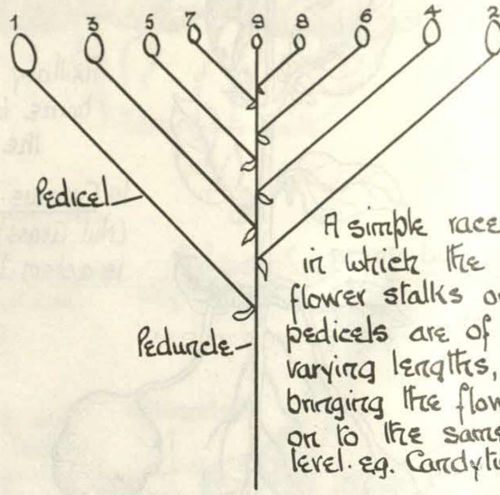
In Foxglove and Toothwort all the flowers are twisted to one side.

II Compound Raceme or Panicle



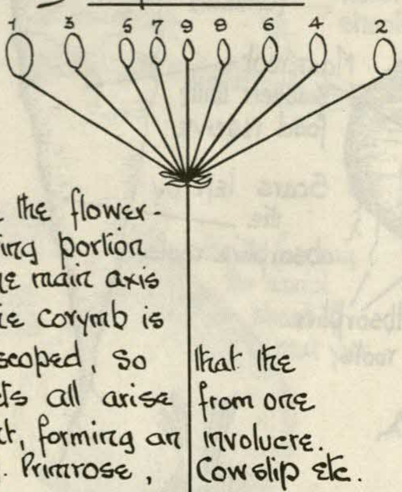
Here each axillary flower of the simple raceme, is replaced by a small raceme, making the compound structure. e.g. Grasses, Yucca etc.

III Corymb.



A simple raceme in which the flower stalks or pedicels are of varying lengths, so bringing the flowers on to the same level. e.g. Candytuft etc.

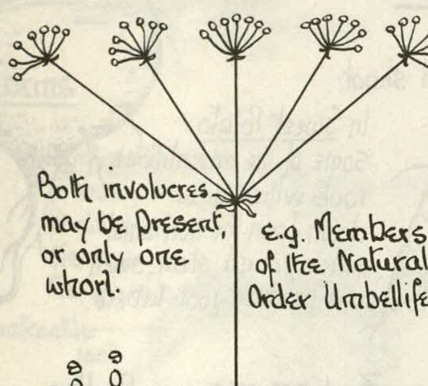
IV Simple Umbel



Here the flower-bearing portion of the main axis of the corymb is telescoped, so that the bracts all arise from one point, forming an involucre. e.g. Primrose, Cowslip etc.

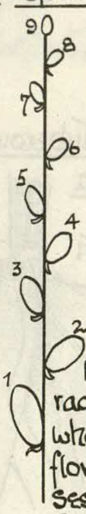
V Compound Umbel

Each flower of the simple umbel is replaced by a small umbel.



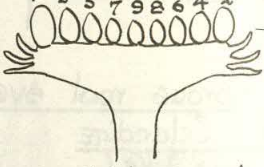
Both involucres may be present, or only one whorl. e.g. Members of the Natural Order Umbelliferae.

VI Spike



A simple raceme in which all the flowers are sessile. e.g. Hazel (male) Plantain etc.

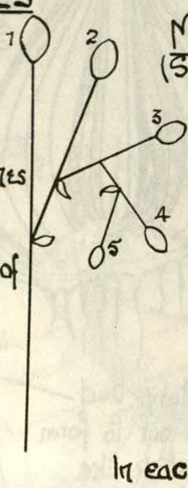
VII Capitulum



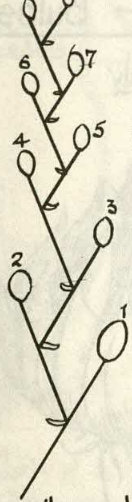
A telescoped spike - the main axis is compressed e.g. Members of the Natural Order Compositae.

b) CYMES

Monochasium. (Simple Cyme)

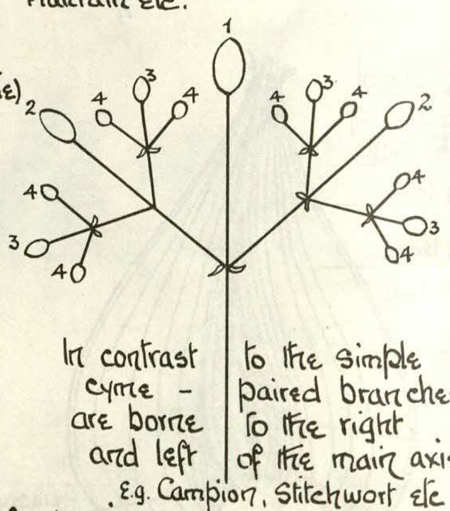


Here the young branches come off from the same side of the parent stem. e.g. Buttercup



In this case the young branches are borne on alternate sides of the parent stem. e.g. Iris

Dichasium (Double Cyme)



In contrast to the simple cyme - paired branches are borne to the right and left of the main axis. e.g. Campion, Stitchwort etc

In each case, the small numbers indicate the order of opening.

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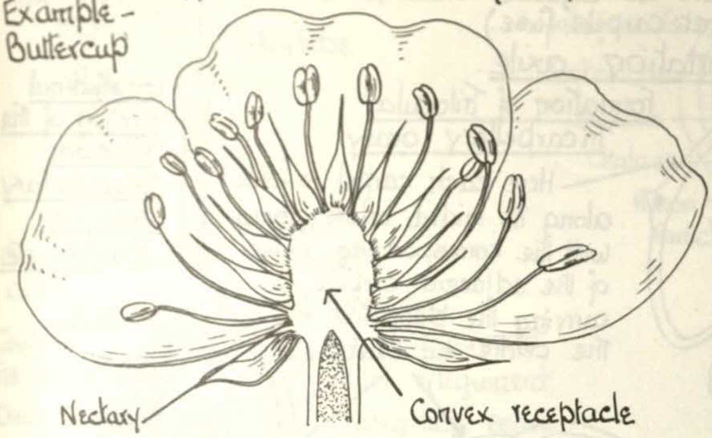
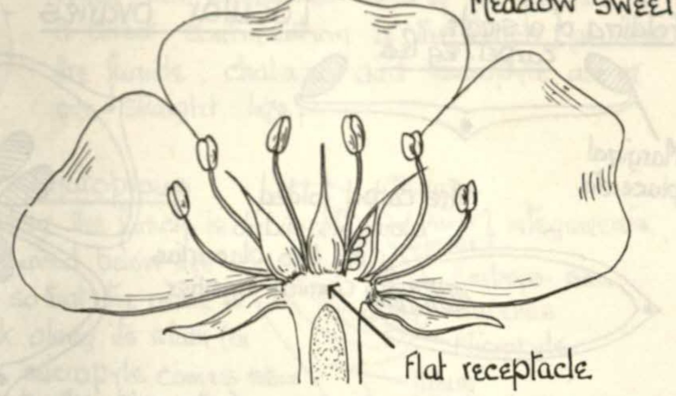
FLOWER STRUCTURE - b) RECEPTACLE

Diagrammatic Longitudinal Sections.

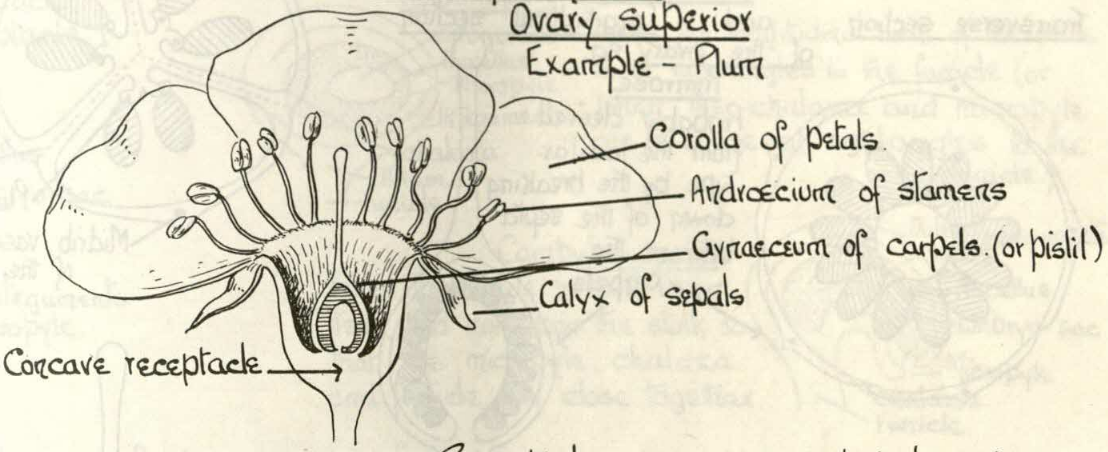
Receptacle convex;
Flower hypogynous; Ovary superior.
Example - Buttercup



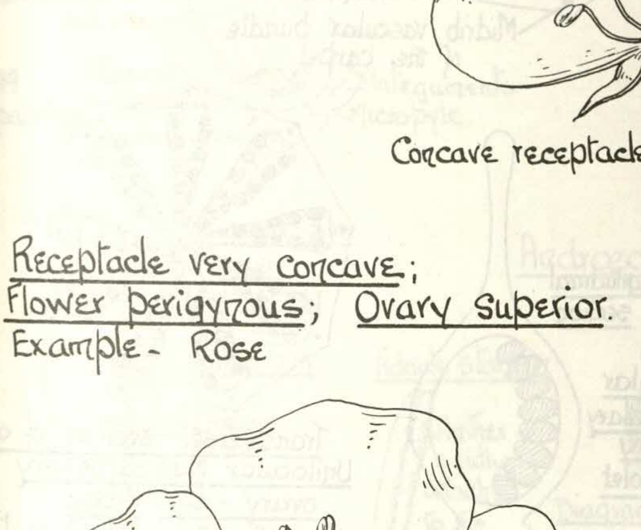
Receptacle flat;
Flower hypogynous; Ovary superior.
Example - Meadow Sweet.



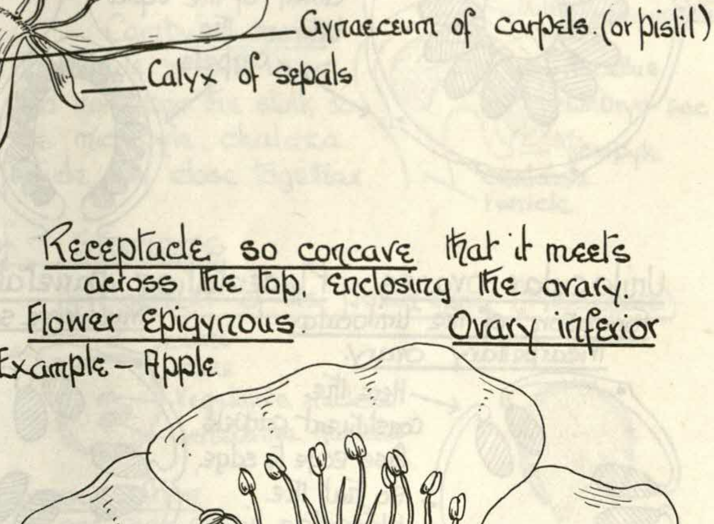
Receptacle concave; Flower perigynous;
Ovary superior
Example - Plum



Receptacle very concave;
Flower perigynous; Ovary superior.
Example - Rose



Receptacle so concave that it meets across the top, enclosing the ovary.
Flower Epigynous. Ovary inferior
Example - Apple



The Ovary is superior in hypogynous and perigynous flowers.
The Ovary is inferior in all Epigynous flowers.

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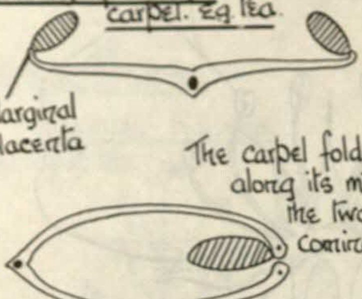
28. FLOWER STRUCTURE c) OVARY AND PLACENTATION

Ovary. I Apocarpous (carpels free from each other) Examples:–
Collection of Follicles. Collection of Achenes; Collection of Drupels.

II Syncarpous (carpels joined together.)
a) Locular (each carpel folded before the adjacent sides fuse)
b) Unilocular (edges of the adjacent carpels fuse.)

Locular ovaries – Placentation axile.

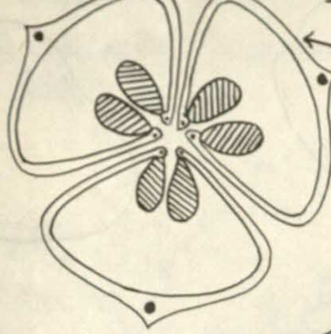
Folding of a single carpel. Eg. Pea



Marginal placenta

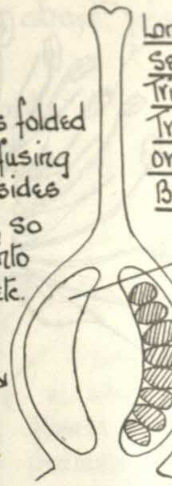
The carpel folded along its midrib – the two placentas coming together

Formation of Trilocular Tricarpellary ovary.

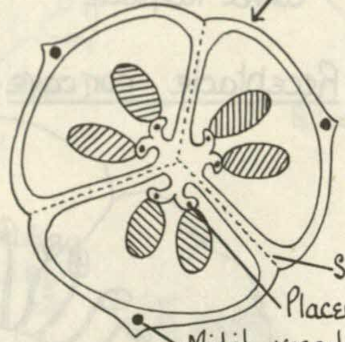


Here each carpel is folded along its midrib before fusing with the corresponding sides of the adjacent carpels, so carrying the placentas into the centre. e.g. Bluebell etc.

Longitudinal section of the Trilocular Tricarpellary ovary – eg. Bluebell etc



Septum.



Transverse section of the Trilocular Tricarpellary ovary. Eg. Bluebell etc.

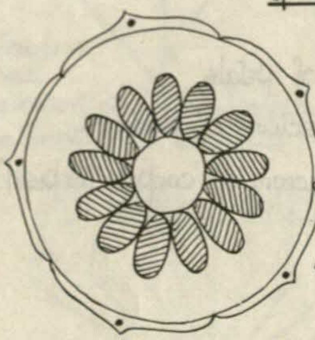
Septum.

Placental vascular bundle.

Midrib vascular bundle of the carpel.

Unilocular ovaries – Placentation free-central.

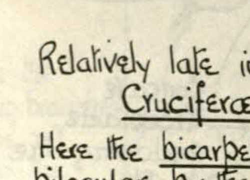
Transverse section and Longitudinal section of the ovary Eg. Primrose.



Probably derived from the locular type by the breaking down of the septa between the carpels.

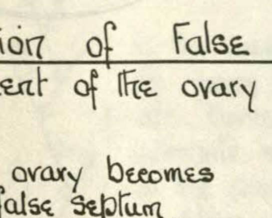
Unilocular ovaries – Placentation parietal

Formation of the Unilocular Tricarpellary ovary.

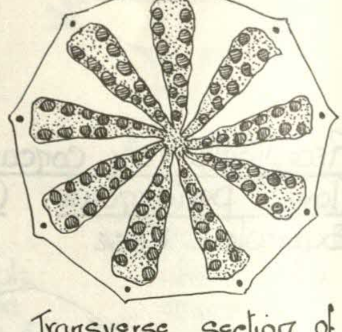


Here the constituent carpels fuse edge to edge, so that the placentas lie along the wall

Transverse section



Longitudinal section of a Unilocular Tricarpellary ovary Eg. Violet

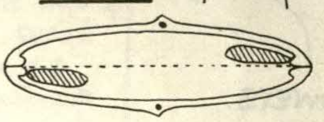


Transverse section of a Unilocular Multicarpellary ovary – e.g. Poppy.
Here the parietal placentas project well into the interior of the ovary.

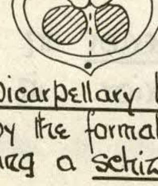
Formation of False Septa.

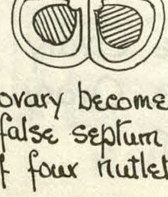
Relatively late in the development of the ovary a false septum or replum arises.— e.g. Cruciferae

Here the bicarpellary unilocular ovary becomes bilocular by the formation of a false septum or replum – the resulting fruit being either a silicula or siliqua according to its shape.



Labiatae and Boraginaceae





Here the bicarpellary bilocular ovary becomes quadrilocular by the formation of a false septum, the resulting fruit being a schizocarp of four nutlets.

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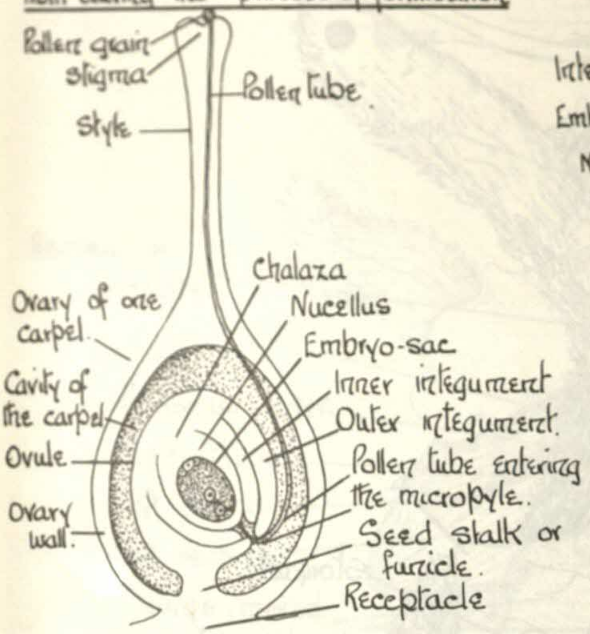
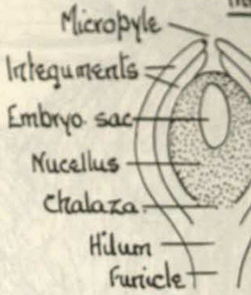
FLOWER STRUCTURE d) PISTIL AND STAMENS

Pistil or Gynaeceum of Carpels

Diagrammatic longitudinal section of the Pistil during the process of fertilisation

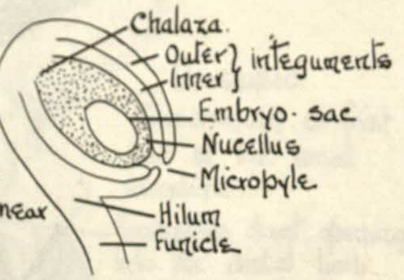


Various types of Ovules – the variation depending upon the relative arrangement of the parts.

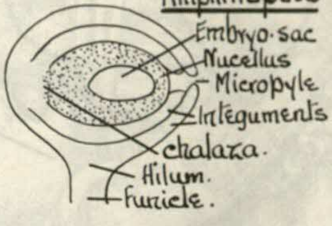


Atropous or Orthotropous
When the longitudinal axis of the nucellus, is a direct continuation of the funicle, (or when the funicle, chalaza and micropyle are in one straight line)

Anatropous
When the funicle is sharply curved below the chalaza, so that the ovule is bent back along its stalk (or when the micropyle comes near to the placenta.)

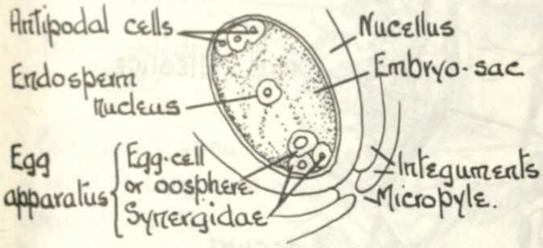


Amphitropous

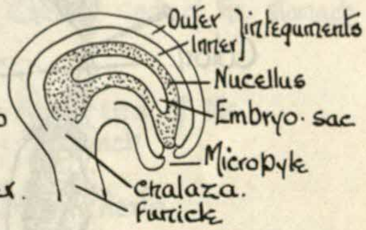


When the longitudinal axis of the ovule is at rightangles to the funicle (or when the chalaza and micropyle are in a line at rightangles to the funicle.)

Embryo-sac.

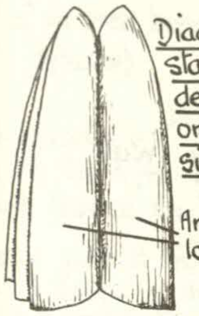


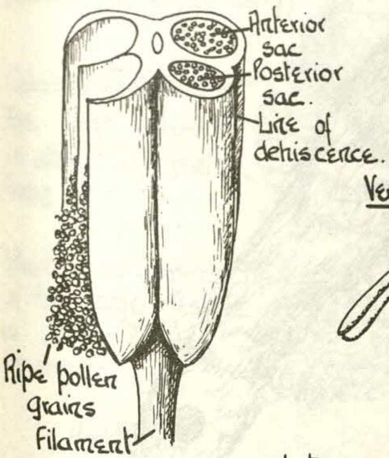
Campylotropous
When the ovule is bent upon itself, and not upon the stalk so that the micropyle, chalaza and funicle are close together.



Androecium of Stamens

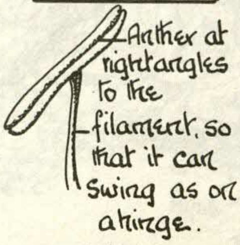
Diagram of a stamen dehiscing on one side only.



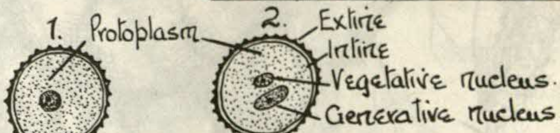


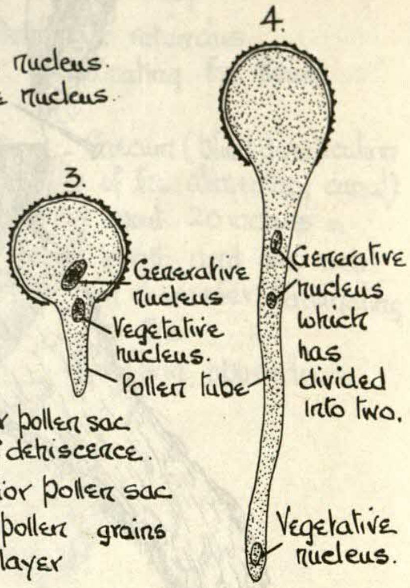
Adnate stamen

Versatile Stamen

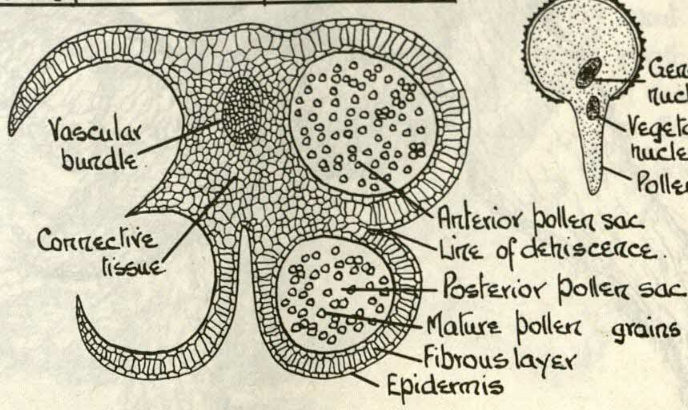


Development of the pollen grain (Microspore)





Diagrammatic transverse section showing dehiscence of one side only.



Introrse dehiscence - When the posterior pollen sacs face the Gynaeceum.
Extrorse dehiscence - When the anterior pollen sacs face the Gynaeceum.

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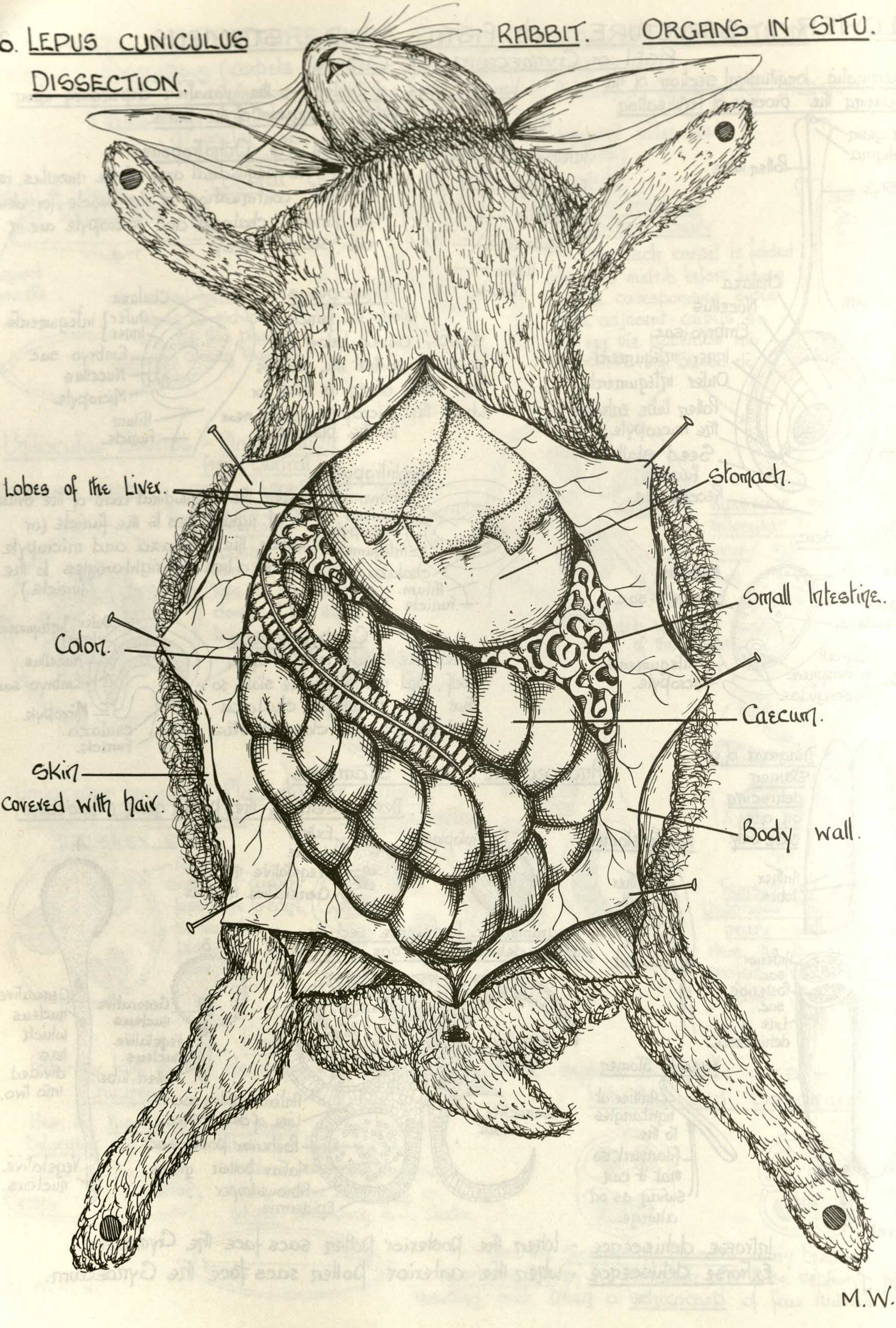
30. LEPUS CUNICULUS DISSECTION. RABBIT. ORGANS IN SITU.



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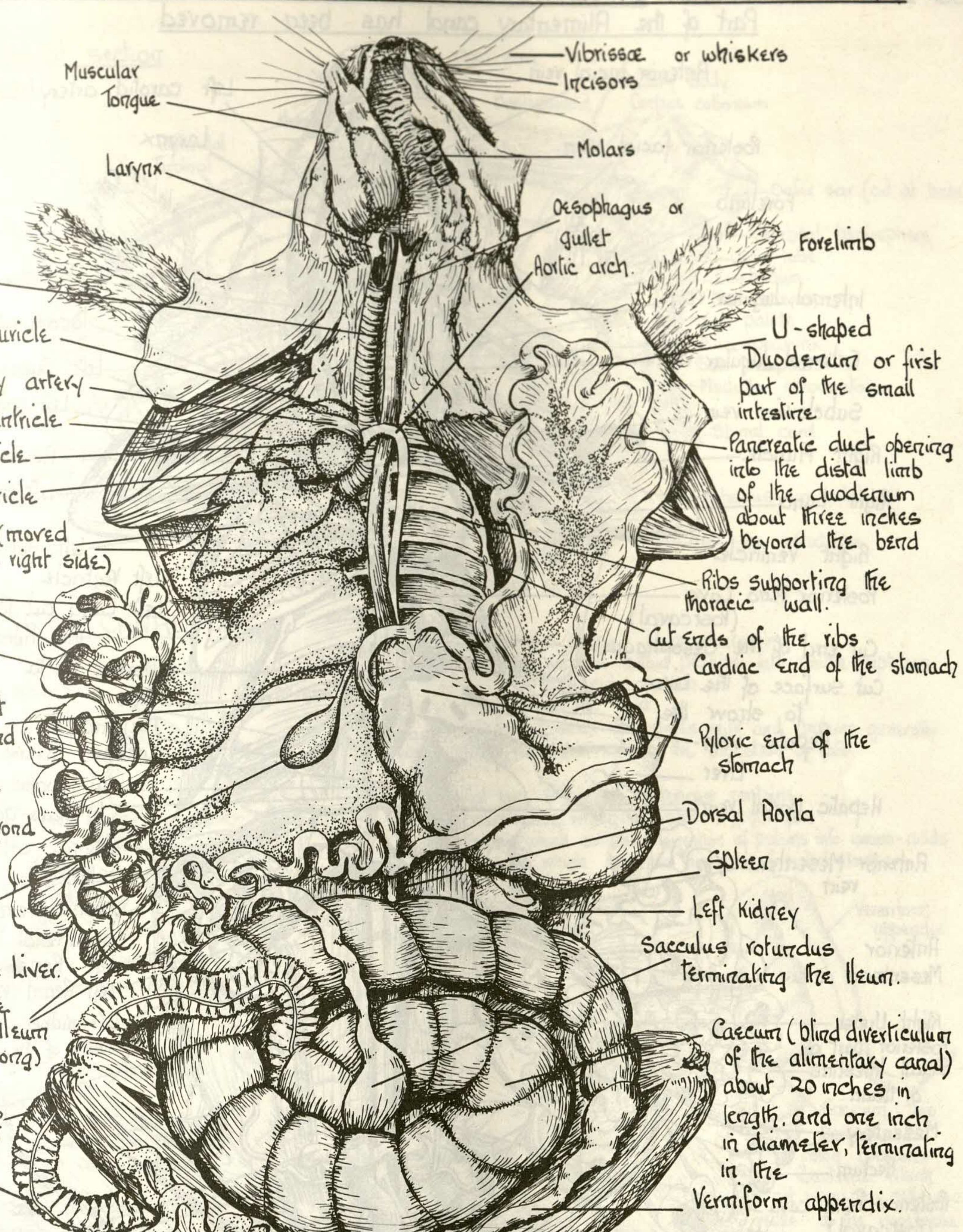
LEPUS CUNICULUS - DISSECTION TO EXPOSE THE ALIMENTARY CANAL.



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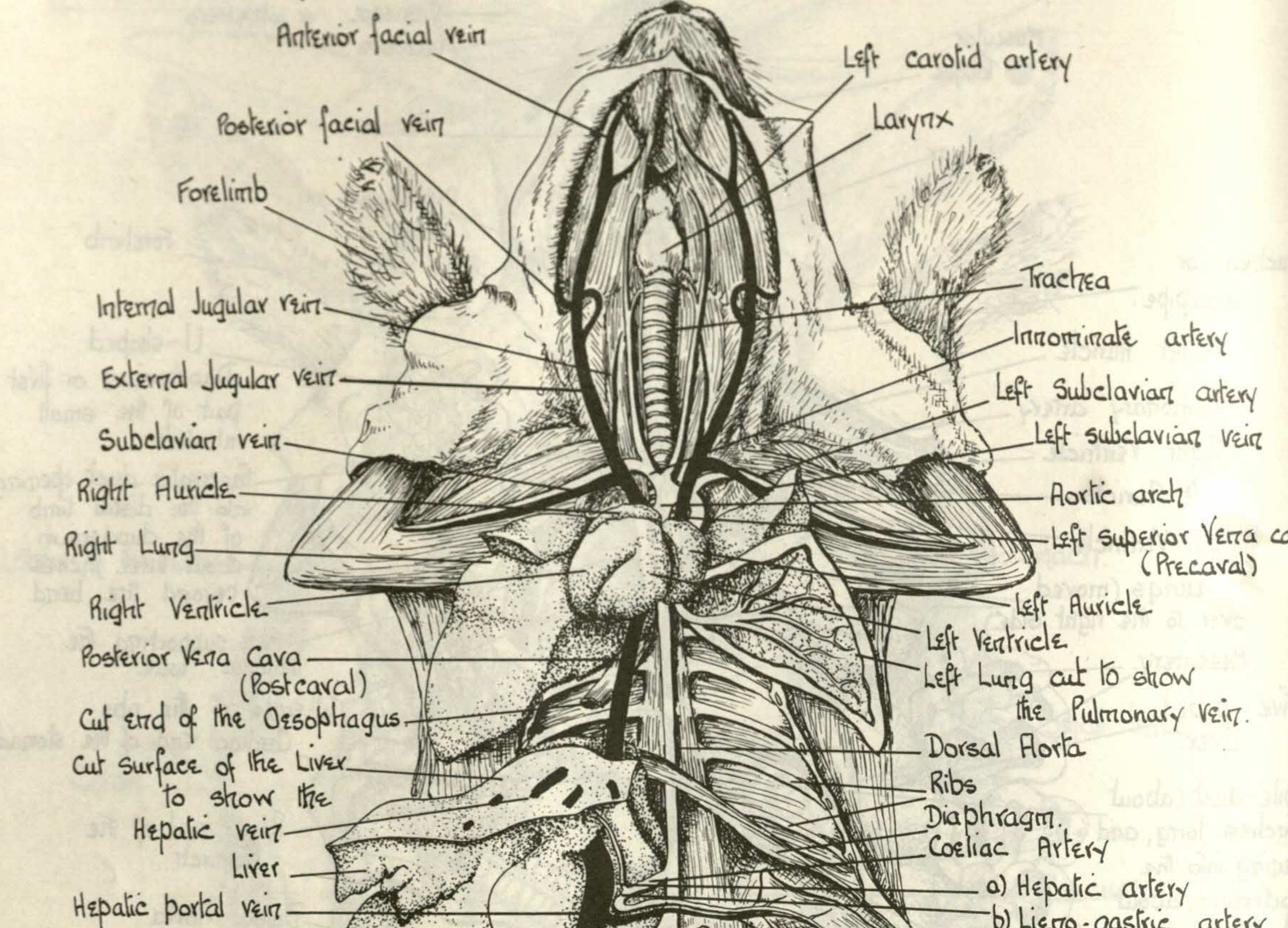
32. LEPUS CUNICULUS - DISSECTION TO SHOW THE CIRCULATORY SYSTEM.

Part of the Alimentary canal has been removed.



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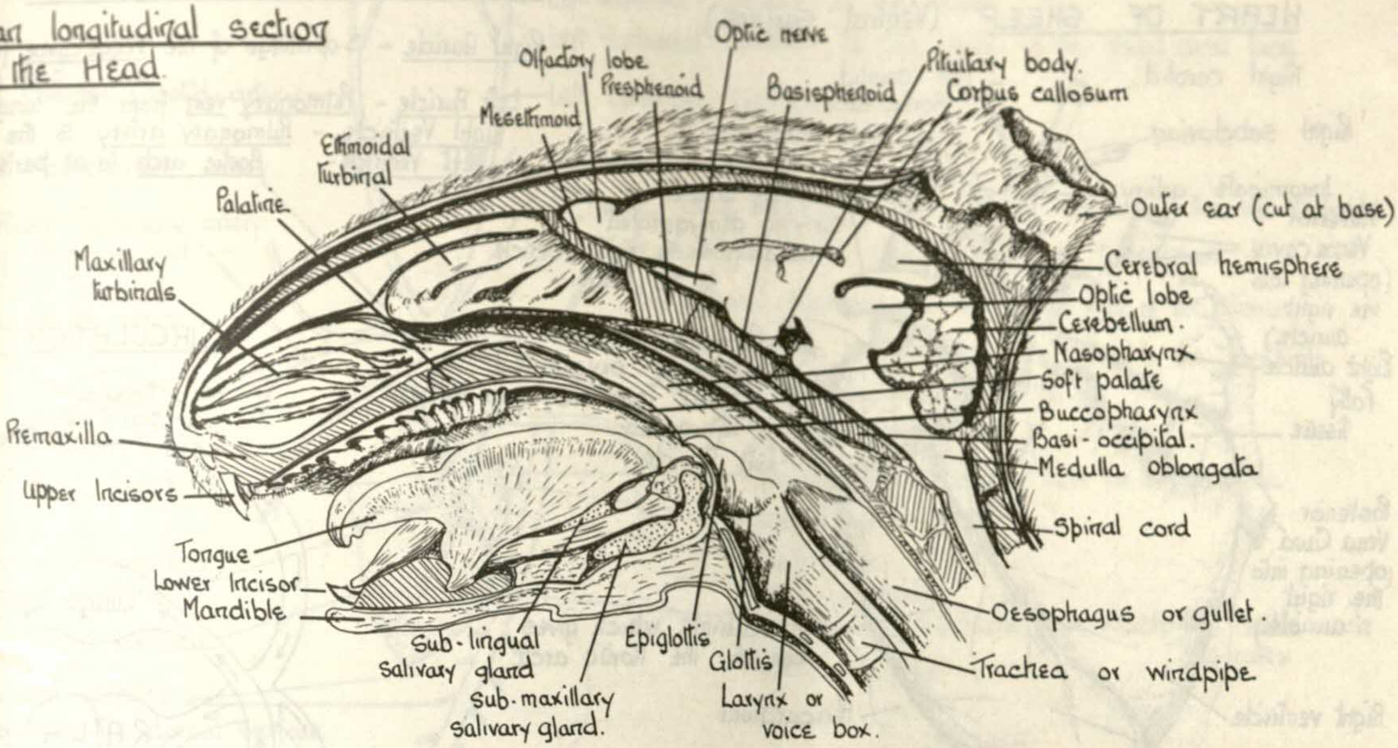
LEPUS CUNICULUS - DIGESTIVE SYSTEM.

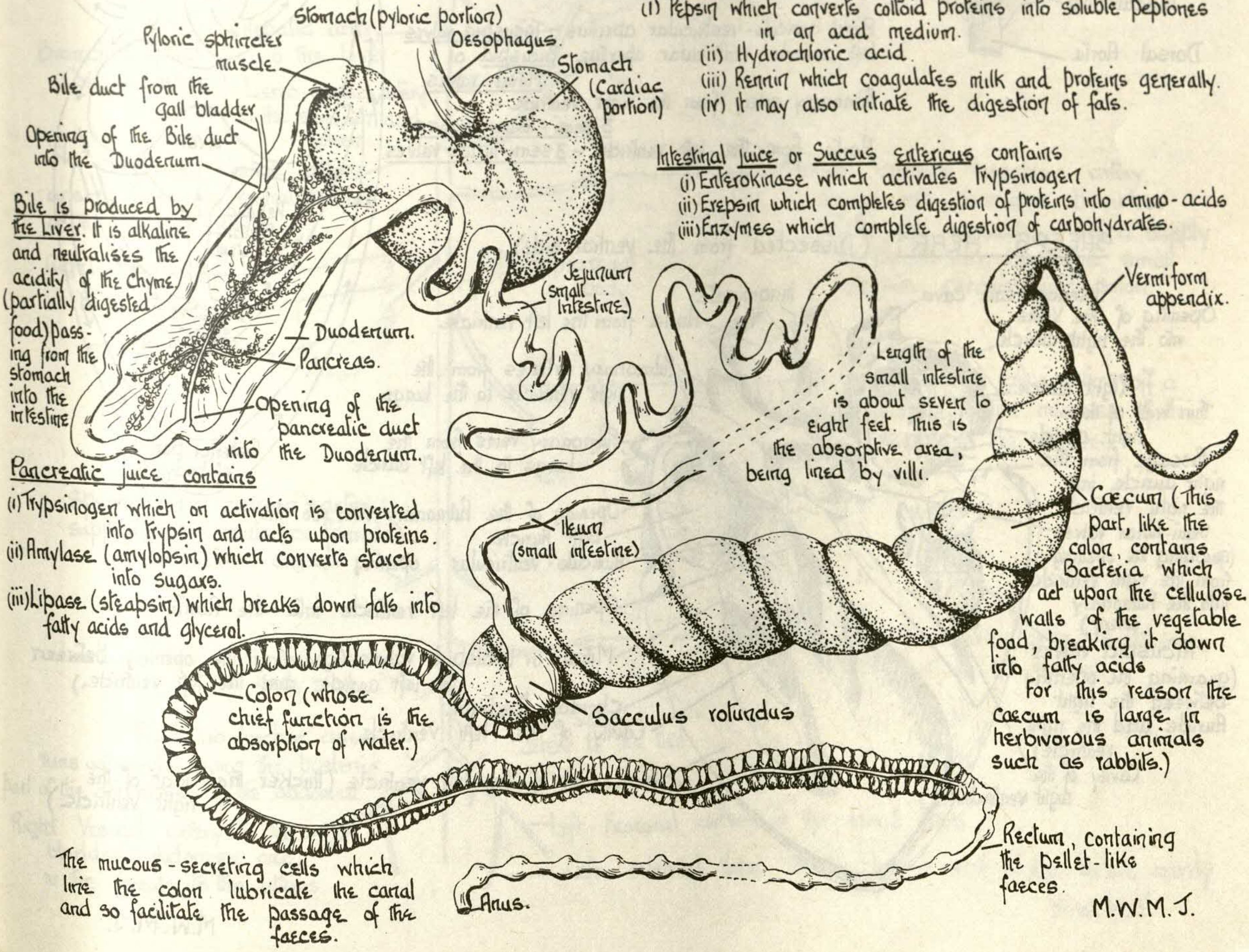
Median longitudinal section of the Head



ALIMENTARY CANAL.

The Stomach secretes Gastric juice containing
(i) Pepsin which converts colloid proteins into soluble peptones in an acid medium.
(ii) Hydrochloric acid.
(iii) Rennin which coagulates milk and proteins generally.
(iv) It may also initiate the digestion of fats.

Intestinal juice or Succus entericus contains
(i) Enterokinase which activates trypsinogen
(ii) Erepsin which completes digestion of proteins into amino-acids
(iii) Enzymes which complete digestion of carbohydrates.



Bile is produced by the Liver. It is alkaline and neutralises the acidity of the Chyme (partially digested food) passing from the stomach into the intestine

Length of the small intestine is about seven to eight feet. This is the absorptive area, being lined by villi.

Caecum (this part, like the colon, contains Bacteria which act upon the cellulose walls of the vegetable food, breaking it down into fatty acids
For this reason the caecum is large in herbivorous animals such as rabbits.)

Pancreatic juice contains
(i) Trypsinogen which on activation is converted into trypsin and acts upon proteins.
(ii) Amylase (amylopsin) which converts starch into sugars.
(iii) Lipase (steapsin) which breaks down fats into fatty acids and glycerol.

The mucous-secreting cells which line the colon lubricate the canal and so facilitate the passage of the faeces.

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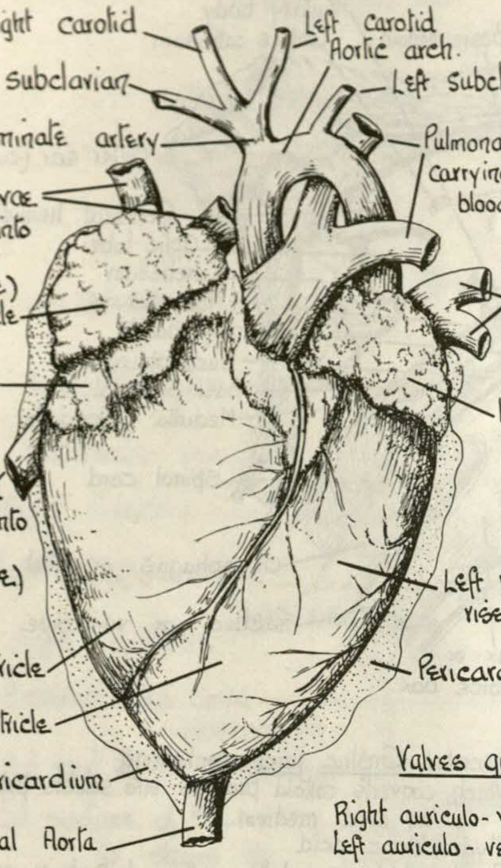
STRUCTURE OF THE MAMMALIAN HEART.

HEART OF SHEEP (Ventral Surface.)



Openings of the vessels into the Heart.

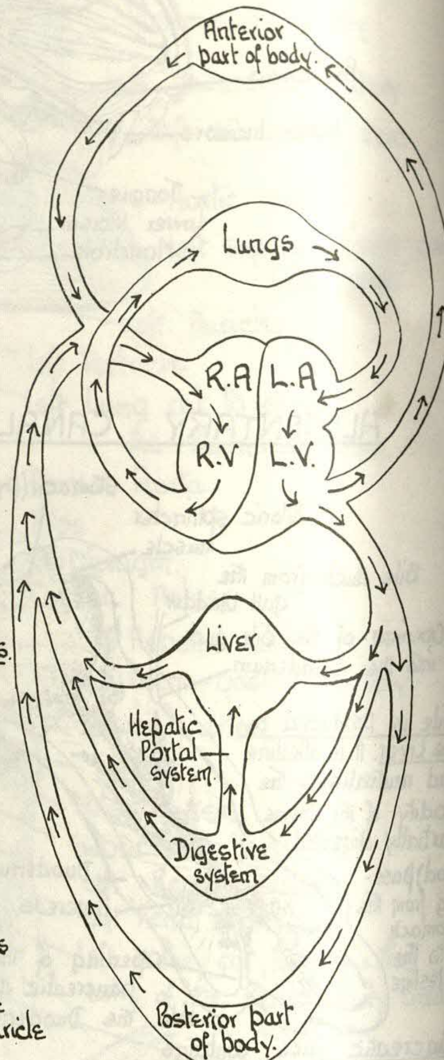
Right Auricle – 3 openings of the Venae Cavae from all parts of the body.

Left Auricle – Pulmonary vein from the lung.

Right Ventricle – Pulmonary artery to the lungs.

Left Ventricle – Aortic arch to all parts of the body.

CIRCULATION



Valves guarding the apertures.

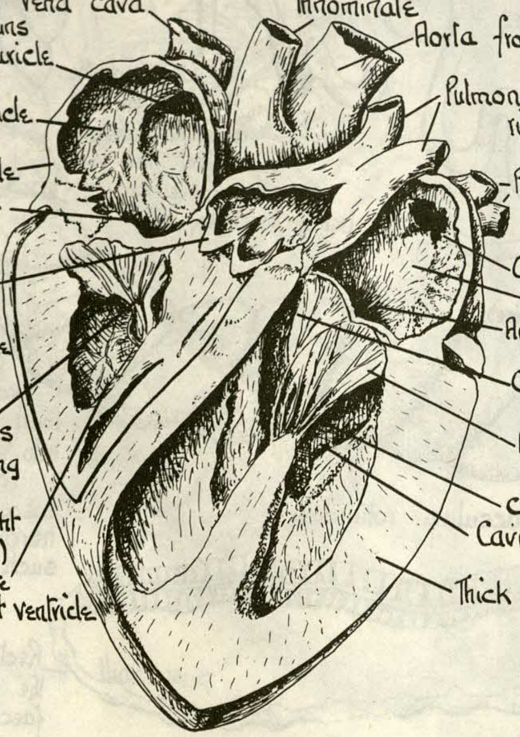
Right auriculo-ventricular aperture – Tricuspid valves.

Left auriculo-ventricular aperture – Bicuspid or Mitral valves.

Pulmonary artery from the right ventricle – 3 semi-lunar valves.

Aorta from the left ventricle – 3 semi-lunar valves.

SHEEP'S HEART (Dissected from the ventral side)



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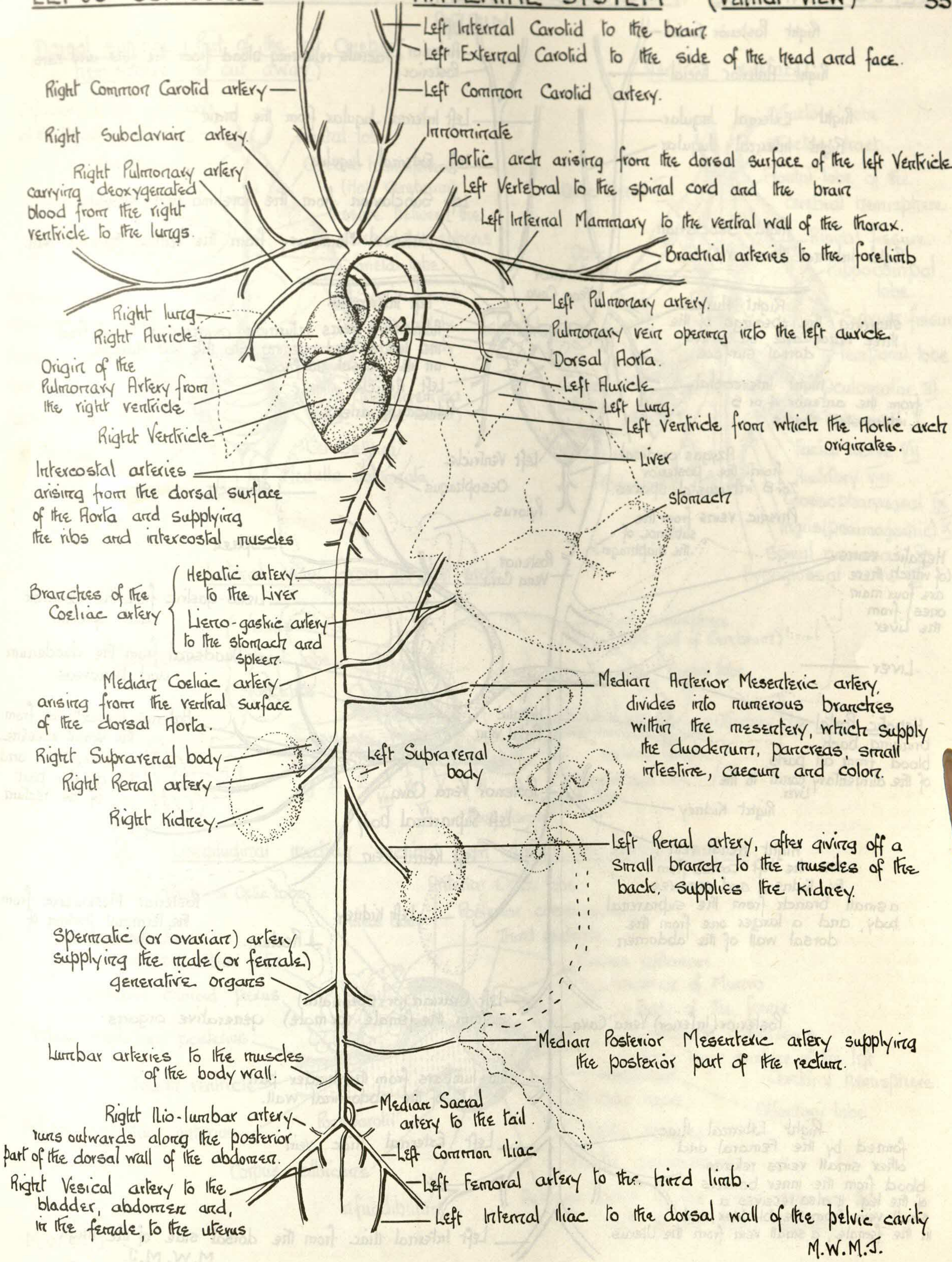
LEPUS CUNICULUS - ARTERIAL SYSTEM - (Ventral view)



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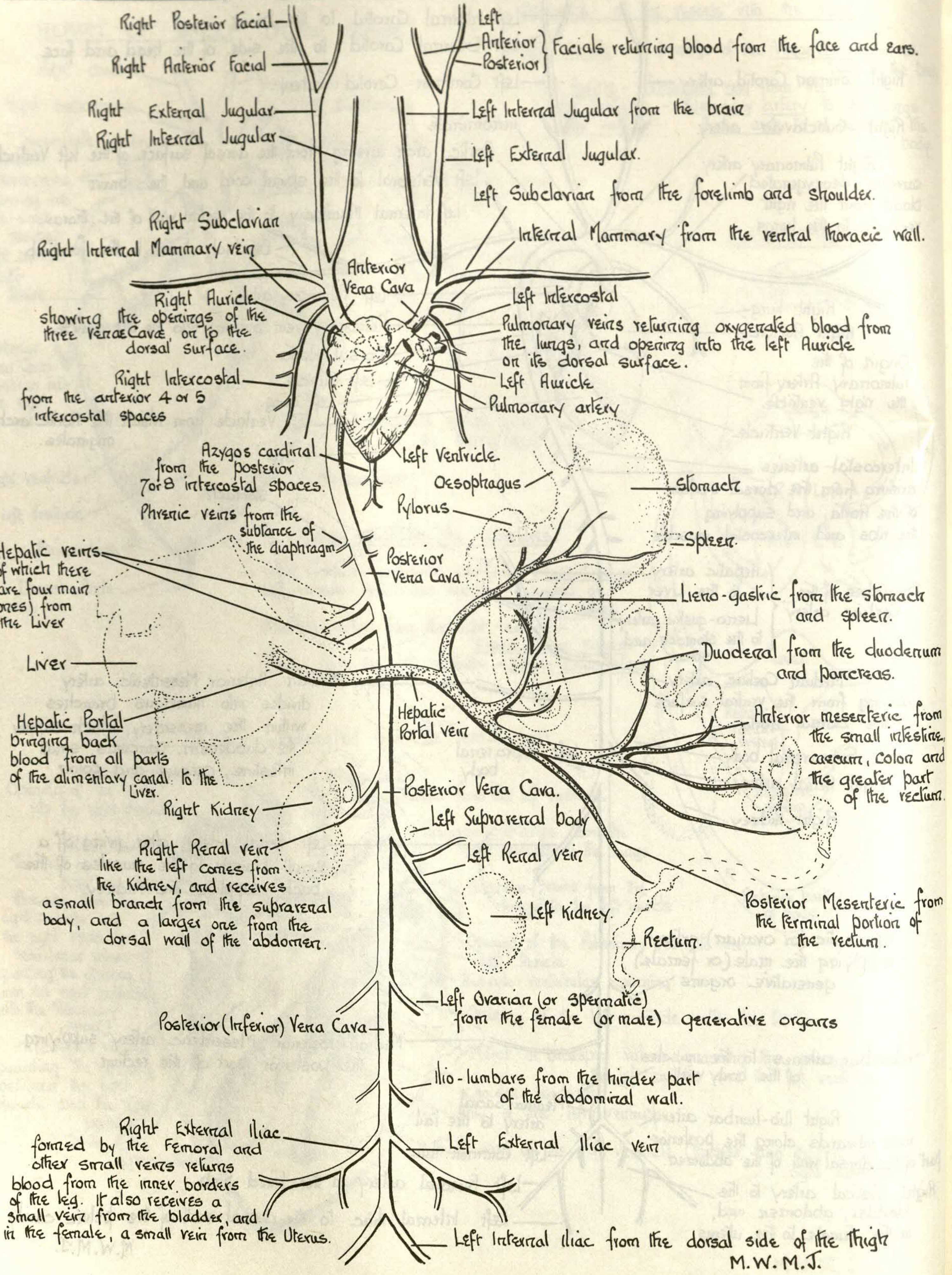
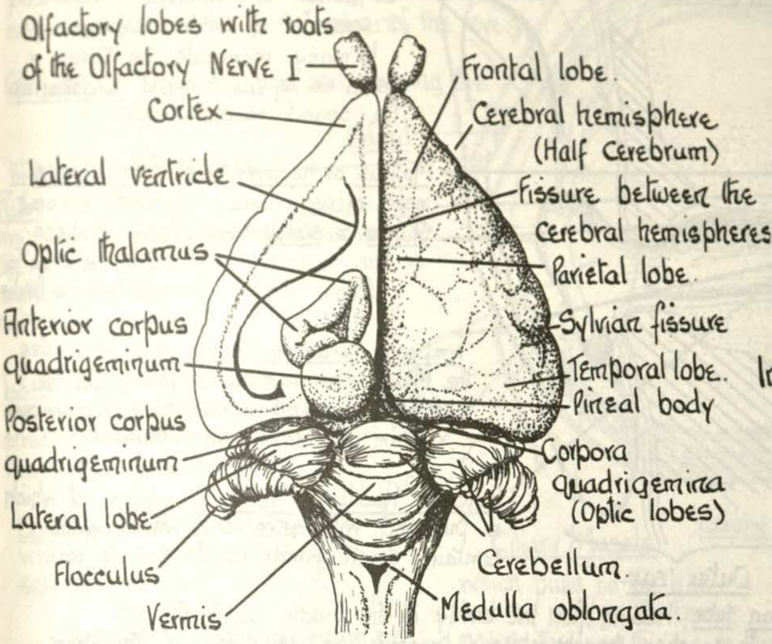
36 LEPUS CUNICULUS - VENOUS SYSTEM. (Ventral view).



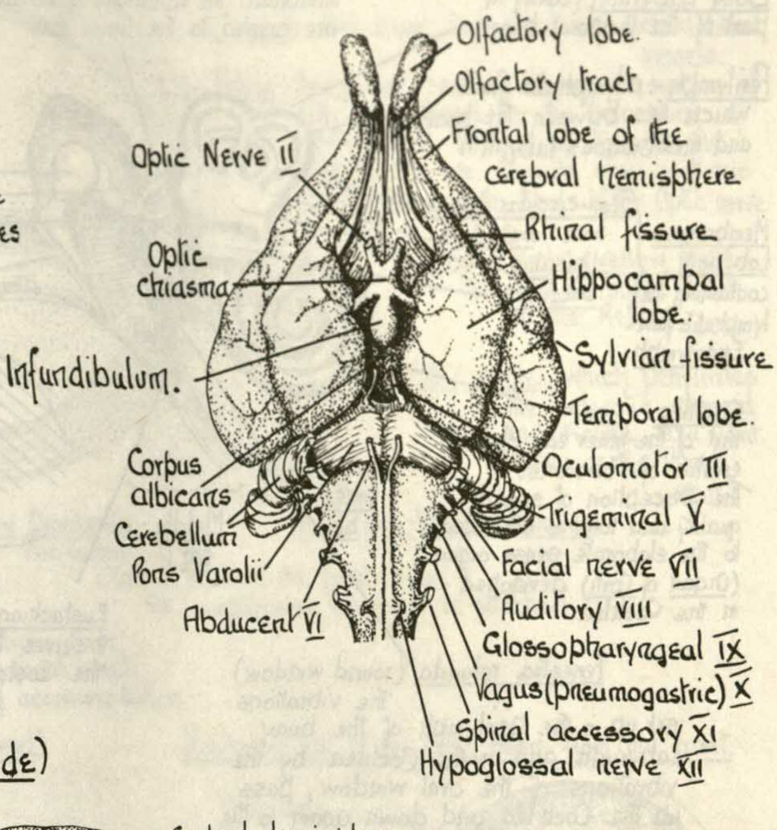
LEPUS CUNICULUS - RABBIT. NERVOUS SYSTEM.

BRAIN.

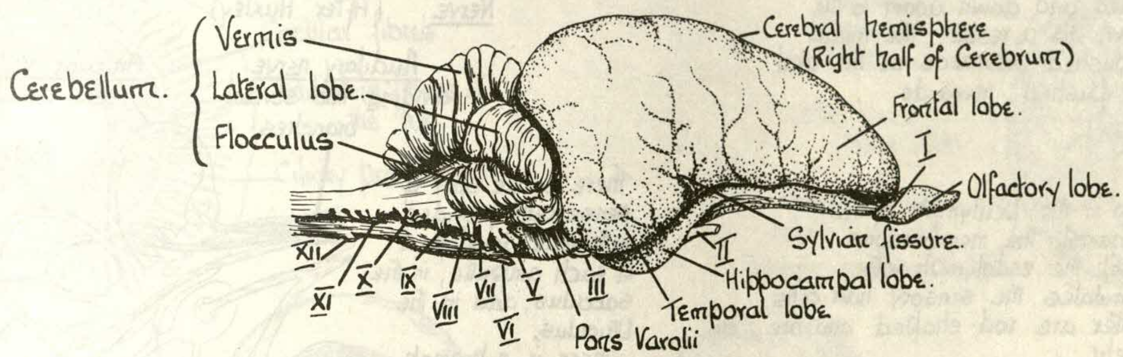
Dorsal surface. (Part of the left Cerebral hemisphere is cut away.)



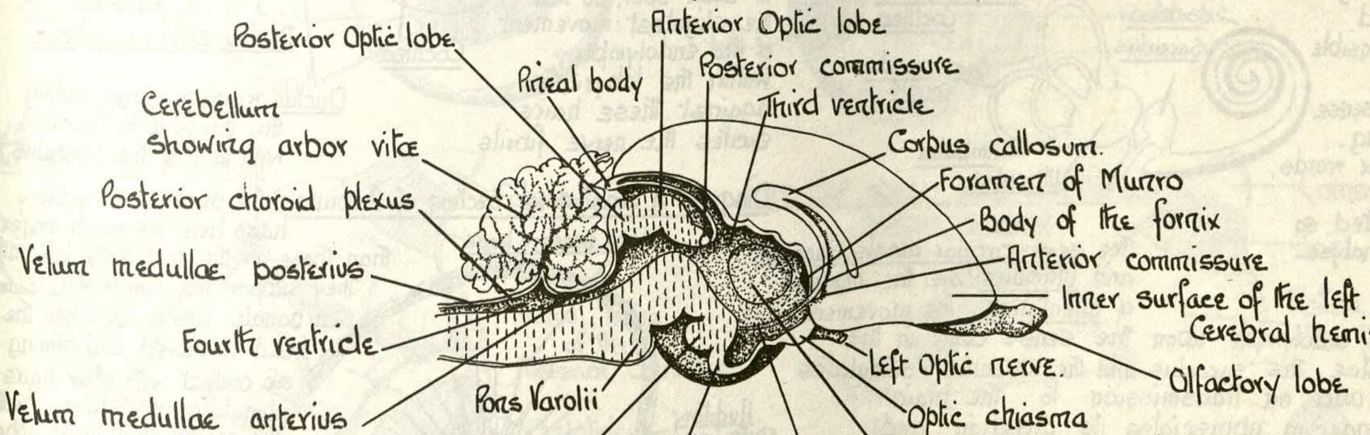
Ventral surface.



Lateral view. (from the left side)



Longitudinal median section from dorsal to ventral surface.



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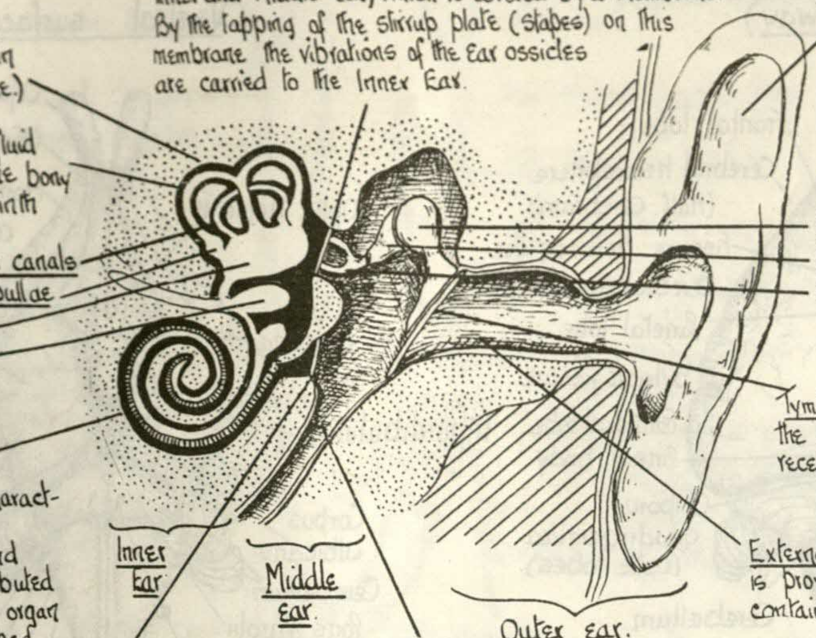
MAMMALS - SENSE ORGANS. THE HUMAN EAR. PARTS AND FUNCTIONS.

DIAGRAM OF THE HUMAN EAR.



Bony Labyrinth (cavity in part of the temporal bone)

Perilymph - a lymphatic fluid which lies between the bony and membranous labyrinth

Membranous Labyrinth containing the lymphatic fluid Endolymph.
- Semi-circular canals with ampullae
- Utriculus
- Sacculus

Cochlea. Part of the Inner ear, characteristic of Mammals. The perception of sound quality and tone is attributed to the elaborate sense organ (Organ of Corti) developed in the Cochlea.

Fenestra ovalis (oval window). - (Opening between the Inner and Middle ear) which is covered by a membrane. By the tapping of the stirrup plate (stapes) on this membrane the vibrations of the Ear ossicles are carried to the Inner Ear.

External Ear (Pinna or concha) which in man, with few exceptions has lost its power of movement. It consists of elastic cartilage. In many mammals the pinna is used as an ear trumpet to gather up the sound waves.

Ear Ossicles which transmit the vibrations from the drum to the Fenestra Ovalis
- Malleus or hammer bone.
- Incus or anvil bone
- Stapes or stirrup bone.

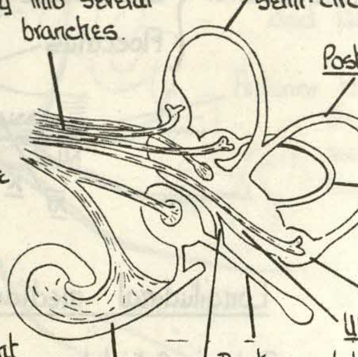
Tympanic membrane or ear drum separates the Middle ear from the Outer ear. On the reception of sound waves, the membraneous drum is thrown into vibrations.

External Auditory Meatus - the entrance of which is provided with hairs, and whose walls contain small glands which secrete wax.

Eustachian tube, leading from the cavity of the middle ear to the pharynx. It serves to equalise the atmospheric pressure on both sides of the drum. The Eustachian tube is homologous with the spiracle of Dogfish.

Fenestra rotunda (round window) The vibrations set up in the perilymph of the bony labyrinth, and in the Cochlea, by the vibrations of the oval window, pass up the Cochlea and down again to the round window. As a result, the round window is pushed outwards as the oval window is pushed inwards

Diagram of the Membranous Labyrinth and Cochlea, to show the endings of the Auditory Nerve. (After Huxley)

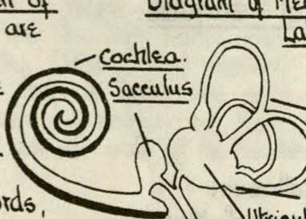


There is one spot of sense cells provided with hairs developed in each ampulla, in the sacculus, and in the Utriculus. There is a branch of the Auditory nerve to each spot, so that the slightest movement of the endolymph, within the labyrinth against these hairs excites the nerve fibrils.

Cochlea

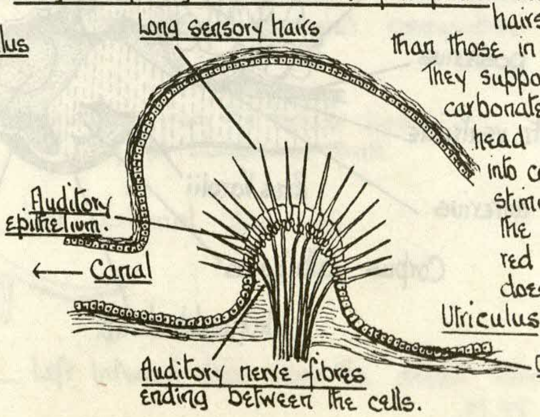
The waves set up in the perilymph of the Cochlea beat against the membranous canal, and so set the endolymph into motion. This stimulates the sensory hair cells. Certain of the latter are rod-shaped and are known collectively as the organ of Corti. They are regarded as responsible for the special sense of hearing. In other words, they are constructed so as to analyse sounds.

Diagram of Membranous Labyrinth and Cochlea.



The semi-circular canals, Sacculus and Utriculus are the organs of orientation. The movement of the endolymph upon the sense cells in the ampullae, the sacculus and the utriculus, stimulates them, and on transmission to the brain the organism appreciates its direction, and rate of movement in space.

Diagram of Longitudinal Section of Ampulla.



The sensory or auditory hairs here are much longer than those in the rest of the labyrinth. They support tiny lumps of Calcium carbonate which roll when the head is moved, and coming into contact with other hairs stimulate other fibres, with the result that what appeared vertical before, no longer does so.

The Mammalian Ear serves
1. to perceive sound quality and tone and
2. to acquaint the mind of the varying positions of the head.

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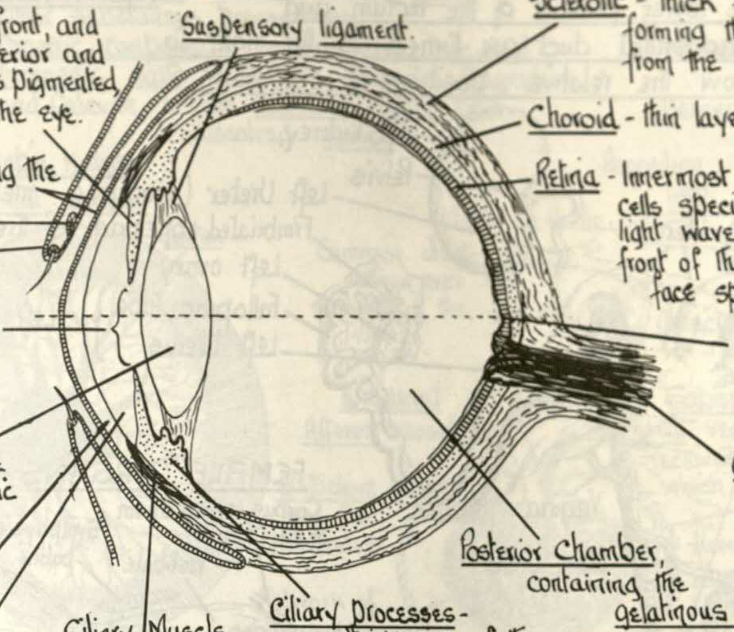
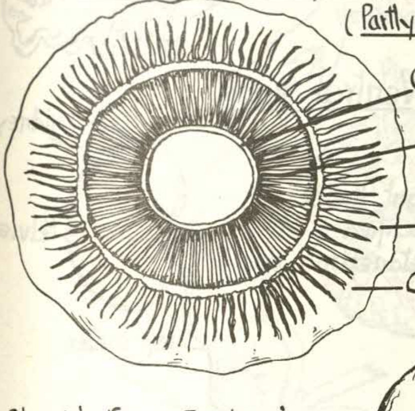
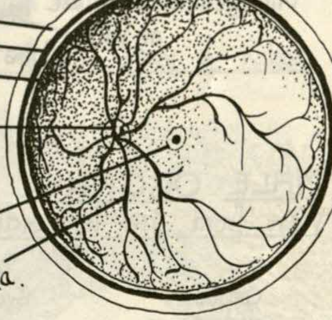
Diagram of the Longitudinal Section of the Human Eye.



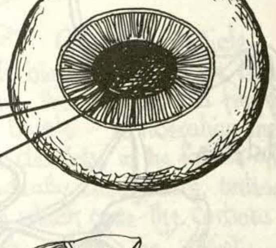
View of Front Half of the Eyeball seen from behind. (Lens removed)
(Partly after Huxley)



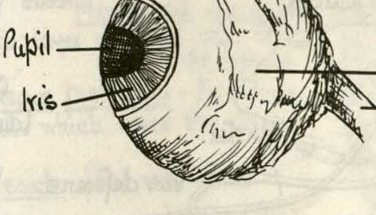
Posterior Half of the Eye, seen from the front.



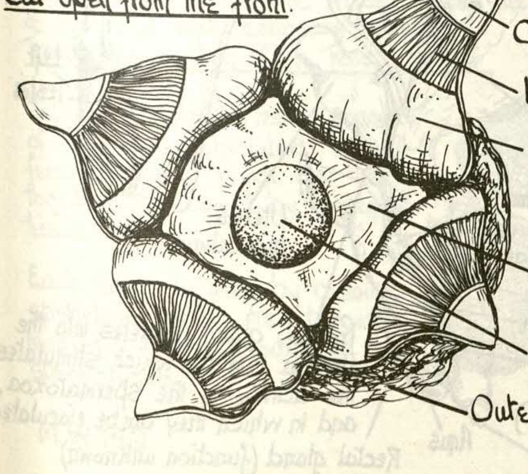
Sheep's Eye. - Front View.



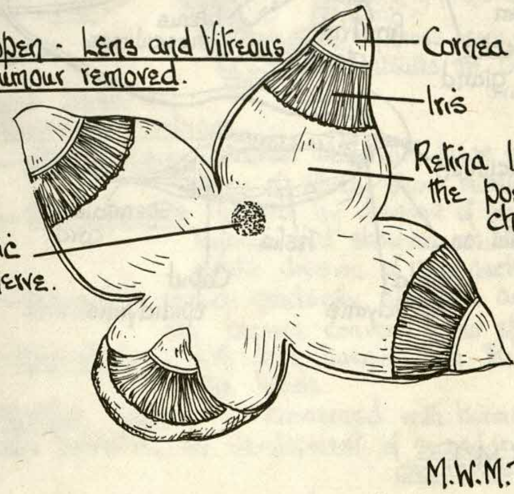
Sheeps Eye - Side View.



Eye cut open from the front.



Eye cut open - Lens and Vitreous humour removed.



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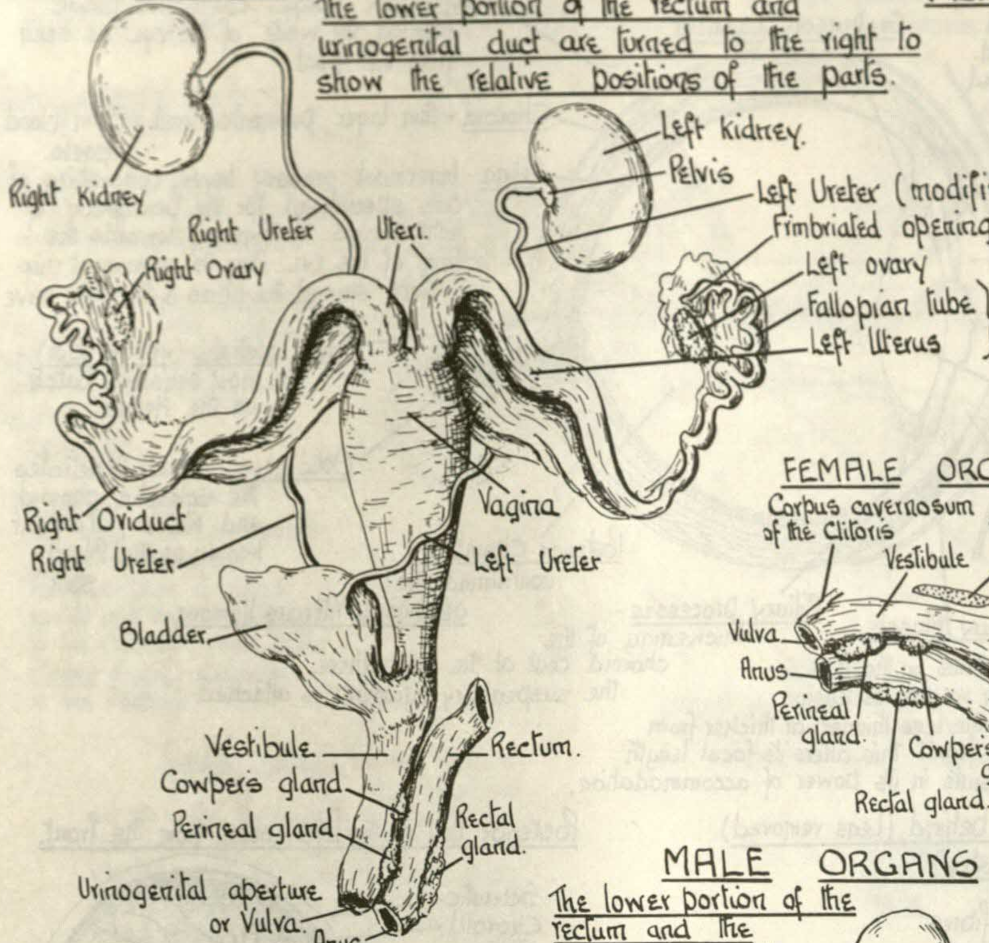
LEPUS CUNICULUS - URINOGENITAL ORGANS.

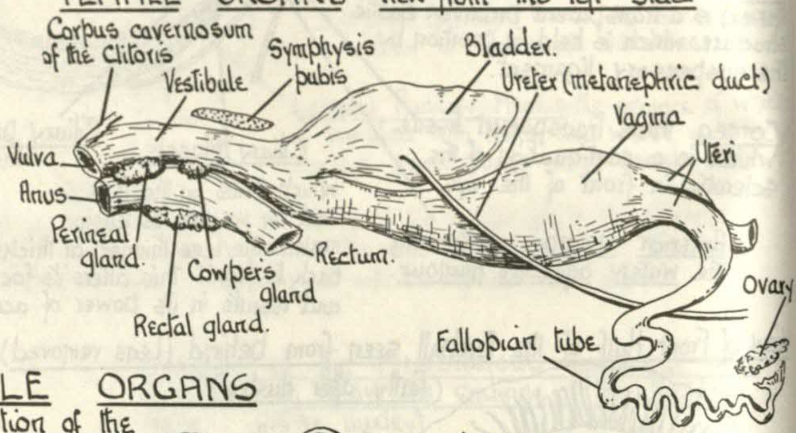
FEMALE ORGANS

Ventral view.

The lower portion of the rectum and urinogenital duct are turned to the right to show the relative positions of the parts.



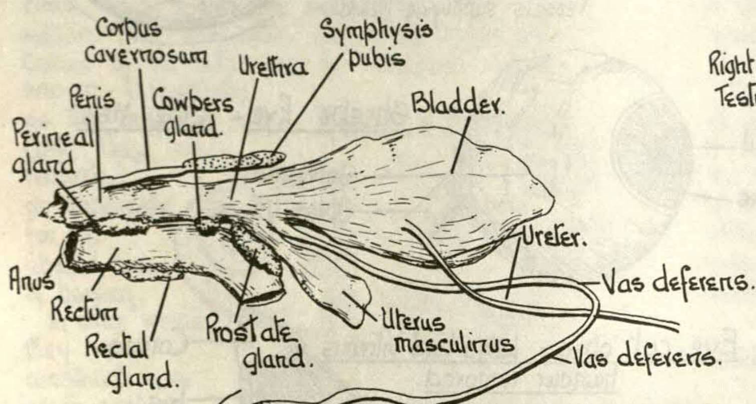
FEMALE ORGANS - View from the left side

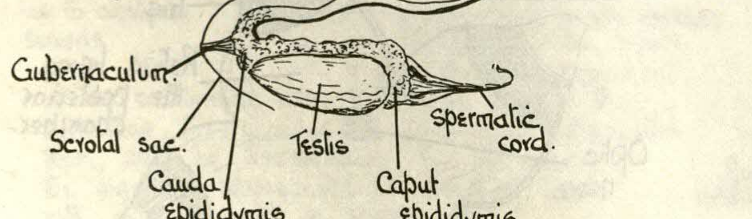


MALE ORGANS

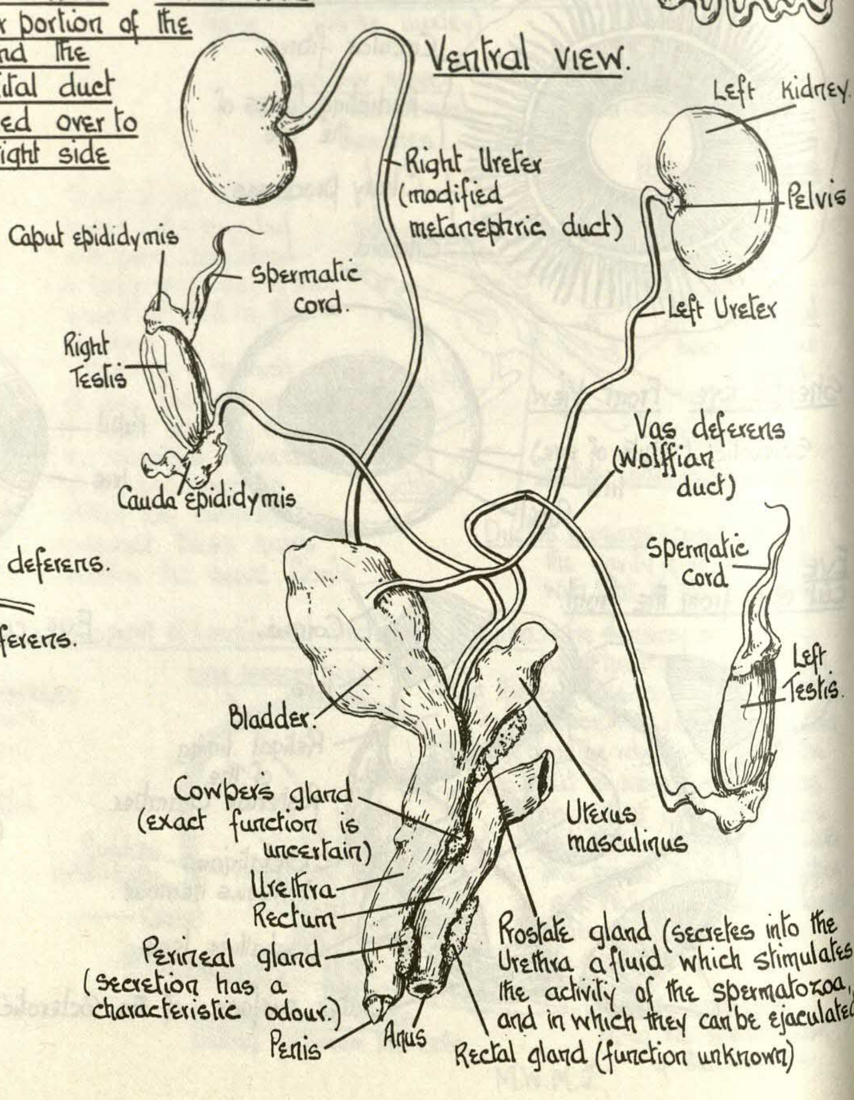
The lower portion of the rectum and the Urinogenital duct are turned over to the right side

MALE ORGANS. View from the left side.





Ventral view.



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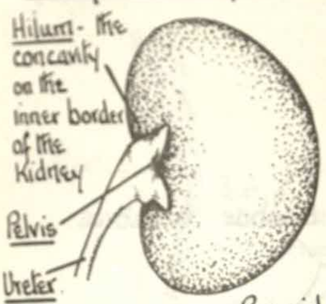
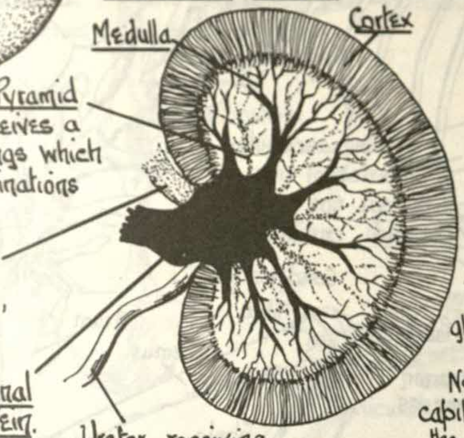
Kidney. (External features).



Renal secretion contains chiefly water. Other substances present are:- Organic compounds such as Urea, Uric acid, Inorganic salts of Sodium, Potassium, Magnesium and Calcium, a little colouring matter and dissolved gases.

Sheep's Kidney Longitudinal section



Uriniferous tubule (Diagram from Hentschel & Cook)

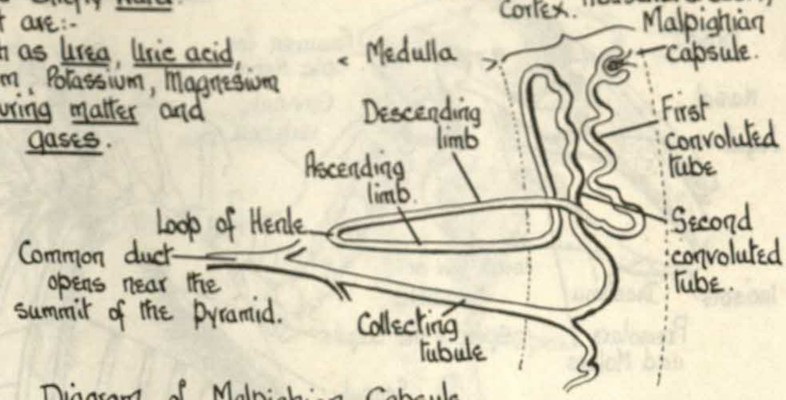
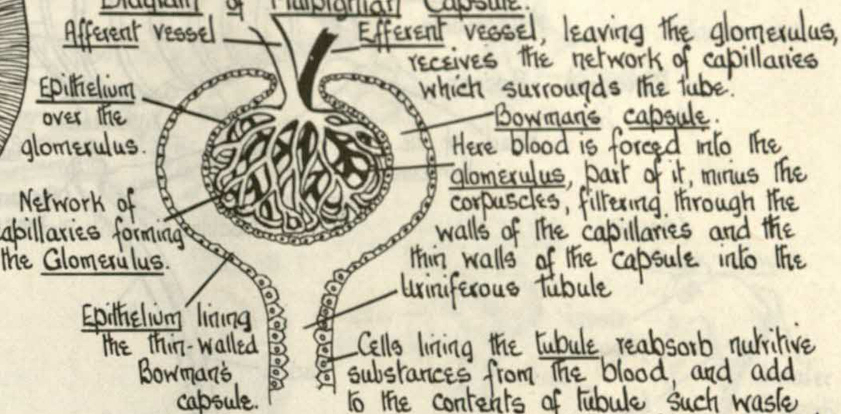
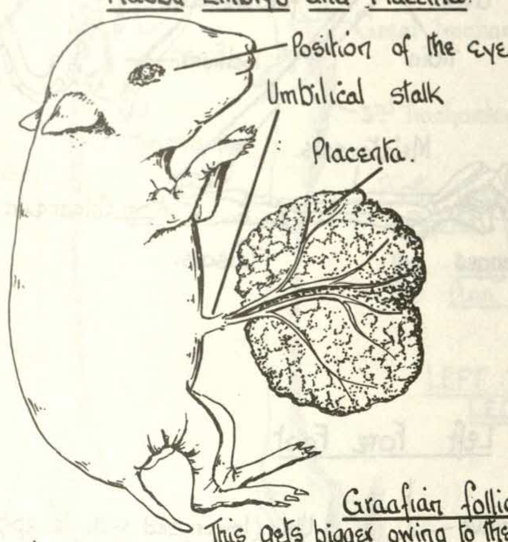


Diagram of Malpighian Capsule.

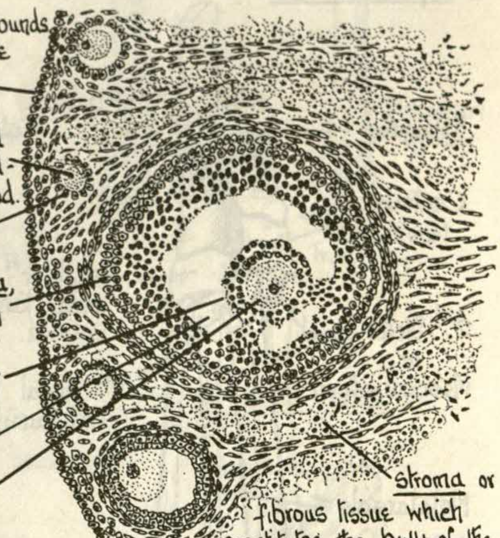


Cells lining the tubule reabsorb nutritive substances from the blood, and add to the contents of tubule such waste matter as Urea, Uric acid, Ammonia etc. The contents of the tubule then pass to the exterior as Urine.

Rabbit Embryo and Placenta.



Transverse section of the Ovary of Rabbit.

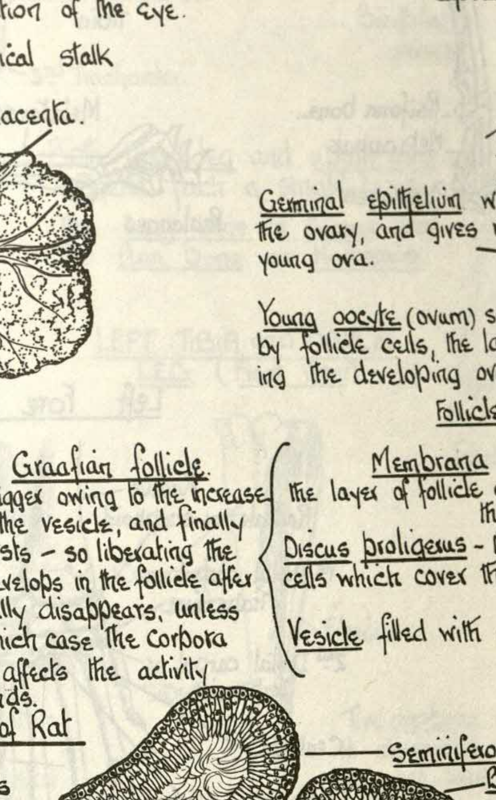


Graafian follicle. This gets bigger owing to the increase in the volume of the fluid within the vesicle, and finally projects from the surface and bursts - so liberating the Ovum. The corpus luteum which develops in the follicle after the liberation of the ovum, gradually disappears, unless the animal becomes pregnant, in which case the corpora lutea produce a hormone which affects the activity of the Uterus and mammary glands.

Transverse section of the Testis of Rat

Typical vertebrate testis consists of numerous convoluted seminiferous tubules, which are held together and bound by connective tissue.

Each tubule is lined by coelomic epithelium which has become modified for the production of spermatozoa.



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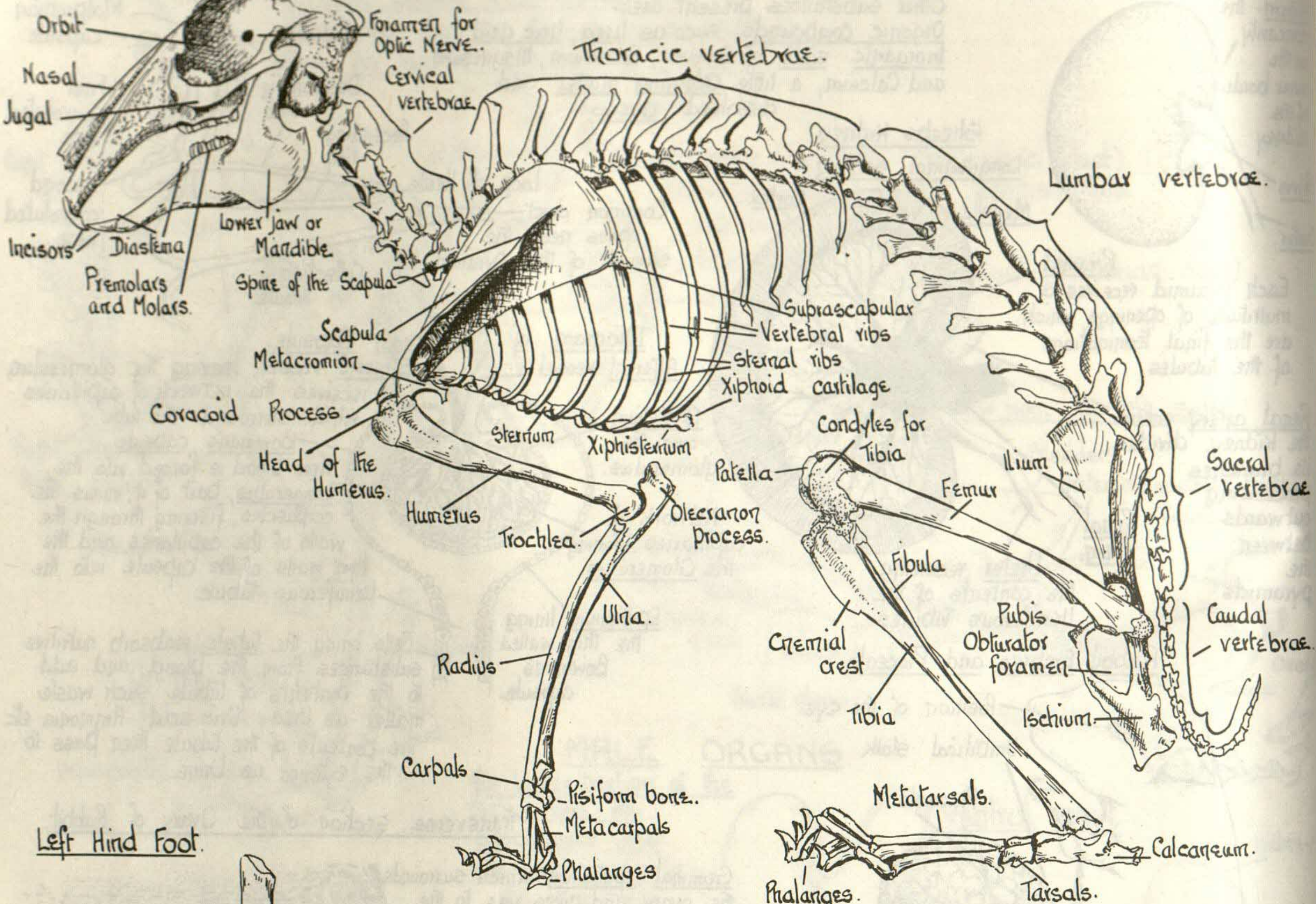
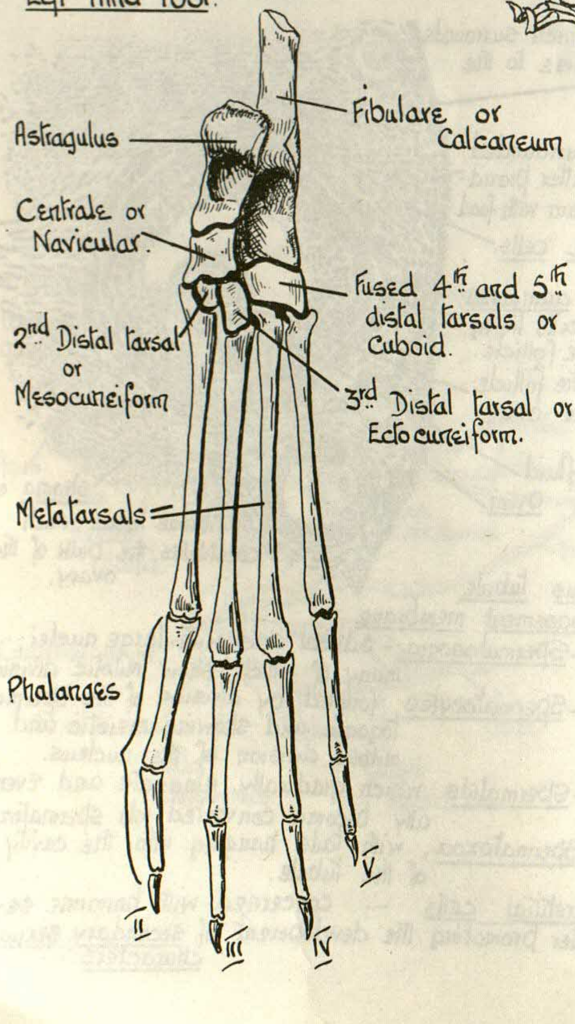
LEPUS CUNICULUS (RABBIT) - SKELETON

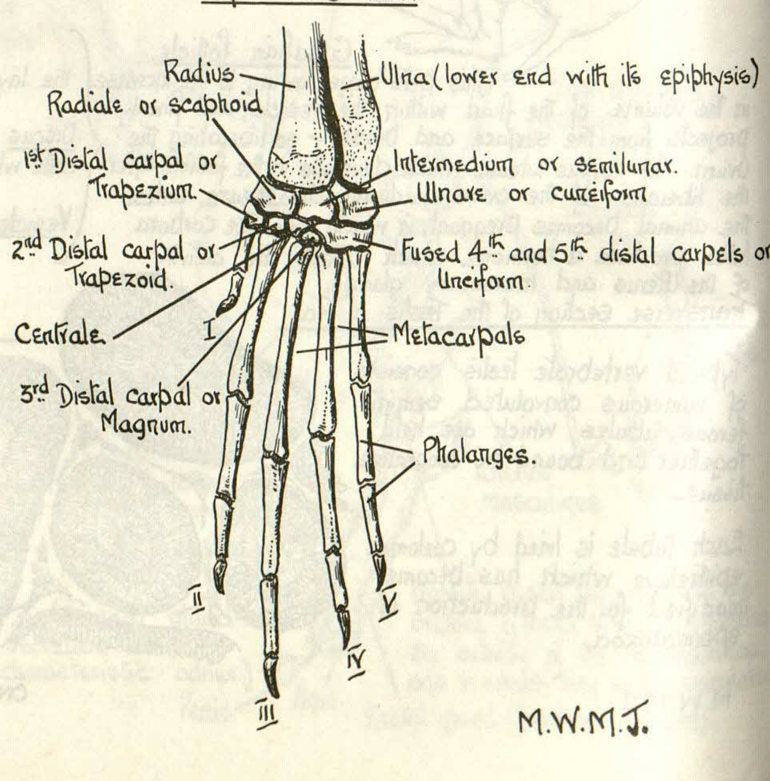
Skeleton from the left side.



Left Hind Foot.



Left Fore Foot



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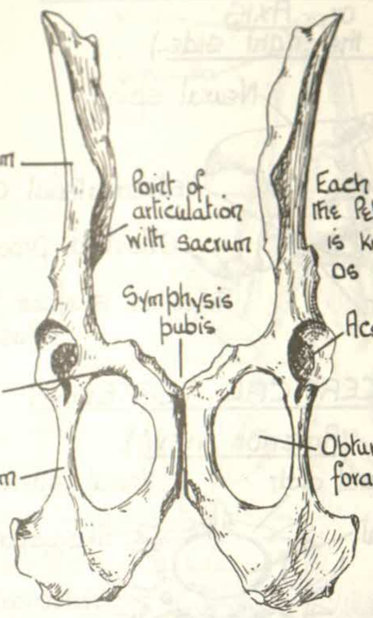
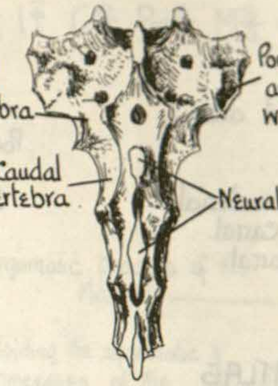
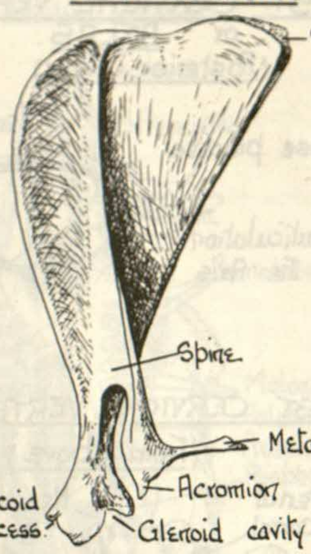
PELVIC GIRDLE (from above)



SACRUM (Dorsal view)

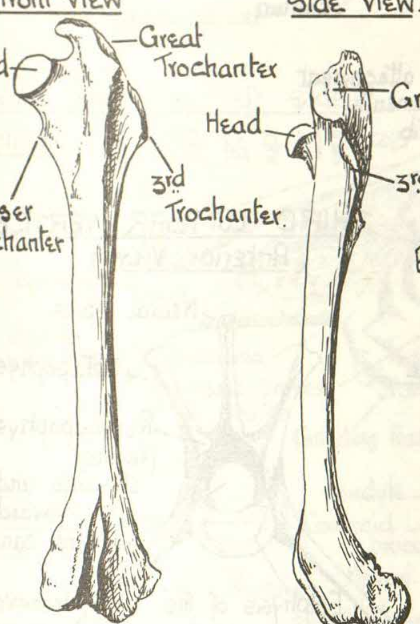


LEFT SCAPULA

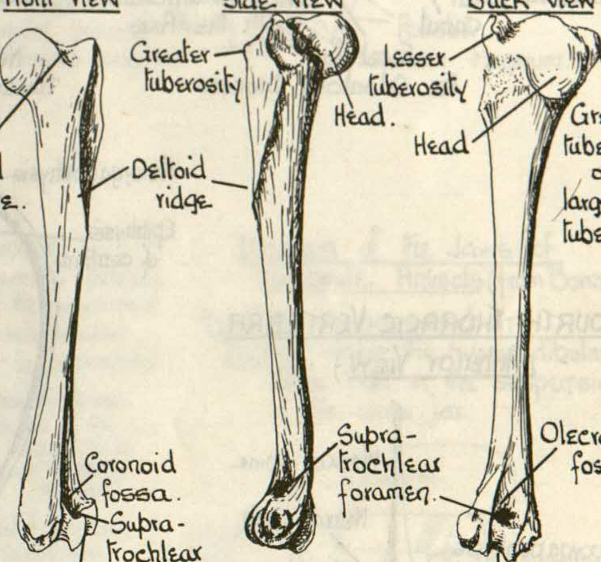


SACRUM (from the right side)

LEFT FEMUR (THIGH)



LEFT HUMERUS (ARM)



Both upper leg and upper arm contain each a single bone. The Leg bone or Femur and the Arm bone or Humerus.

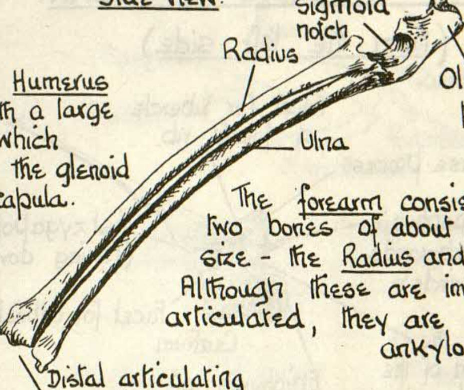
LEFT TIBIA and FIBULA
LEG (Front view)

The upper leg bone or Femur is an elongated bone with a cylindrical shaft and two large extremities. The prominent head articulates with the acetabulum of the Os innominatum, while the distal end bears two large condyles which articulate with the Tibia.

The lower leg contains two bones of unequal size - the larger Tibia and the smaller Fibula. In the adult, the distal portion of the Fibula is completely fused with the Tibia.

The armbone or Humerus is elongated with a large proximal head which articulates with the glenoid cavity of the Scapula.

LEFT RADIUS and ULNA
(FOREARM)



The forearm consists of two bones of about equal size - the Radius and Ulna. Although these are immovably articulated, they are not ankylosed.

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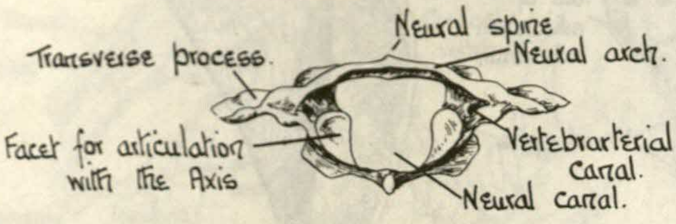
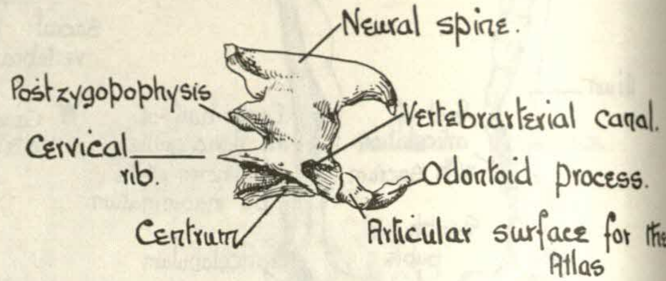
LEPUS CUNICULUS SELECTED VERTEBRÆ.

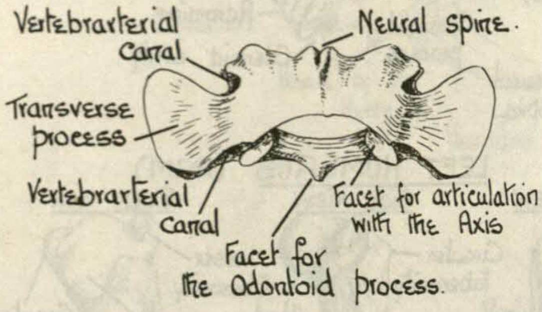
FIRST CERVICAL VERTEBRA or ATLAS. (Posterior View.)



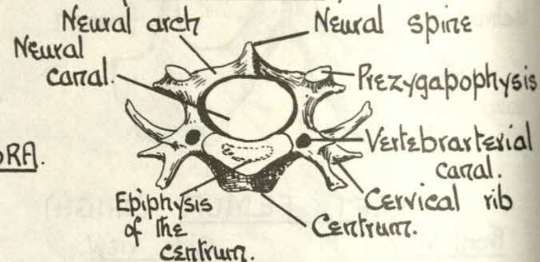
SECOND CERVICAL VERTEBRA or AXIS (from the right side.)



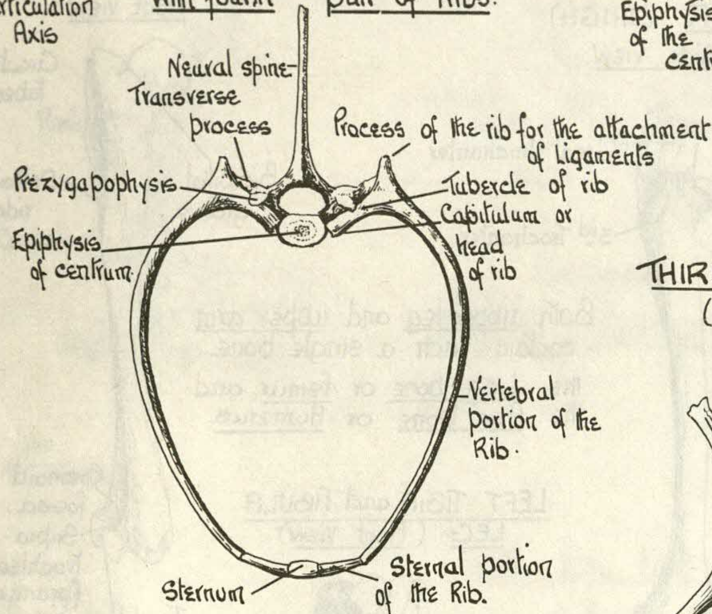
FIRST CERVICAL VERTEBRA or ATLAS (From above.)



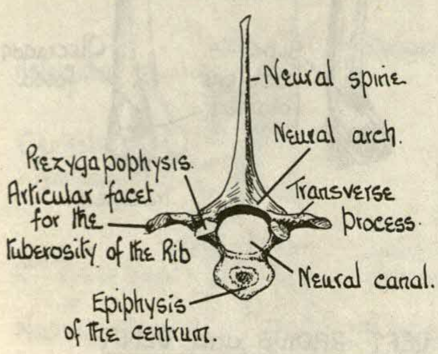
FIFTH CERVICAL VERTEBRA (Anterior view.)



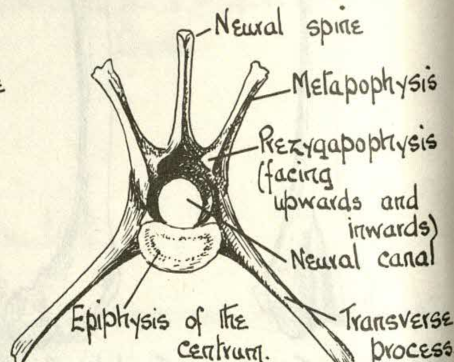
FOURTH THORACIC VERTEBRA. With fourth pair of Ribs.



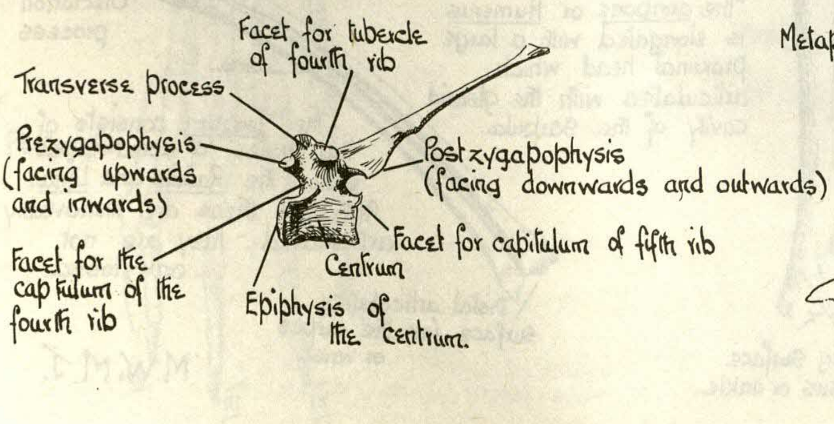
FOURTH THORACIC VERTEBRA (Anterior View.)



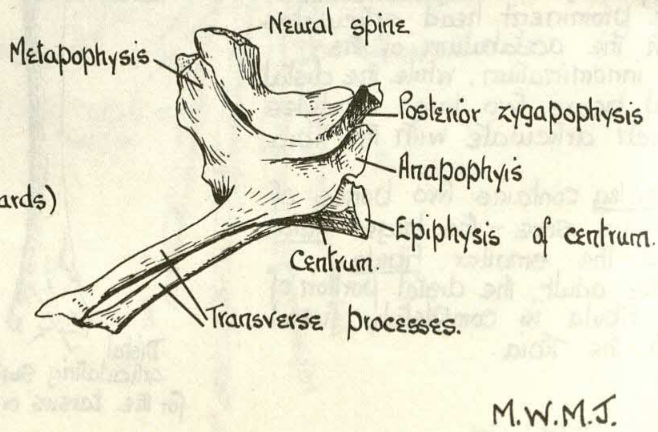
THIRD LUMBAR VERTEBRA (Anterior View.)



FOURTH THORACIC VERTEBRA. (From the left side.)



THIRD LUMBAR VERTEBRA. (From the left side.)

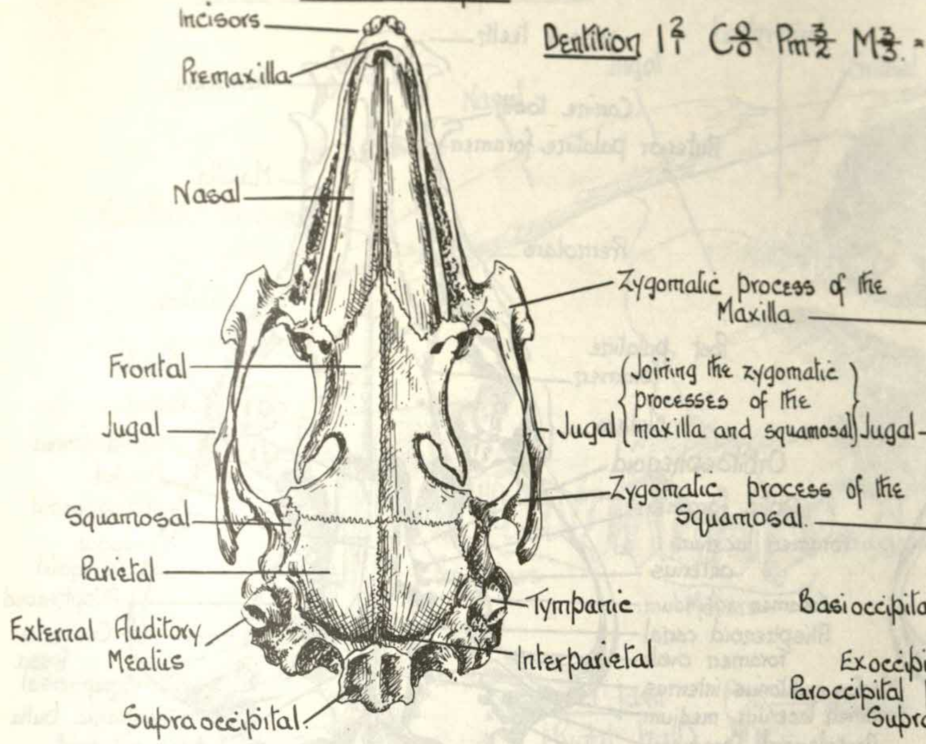


M.W.M.J.

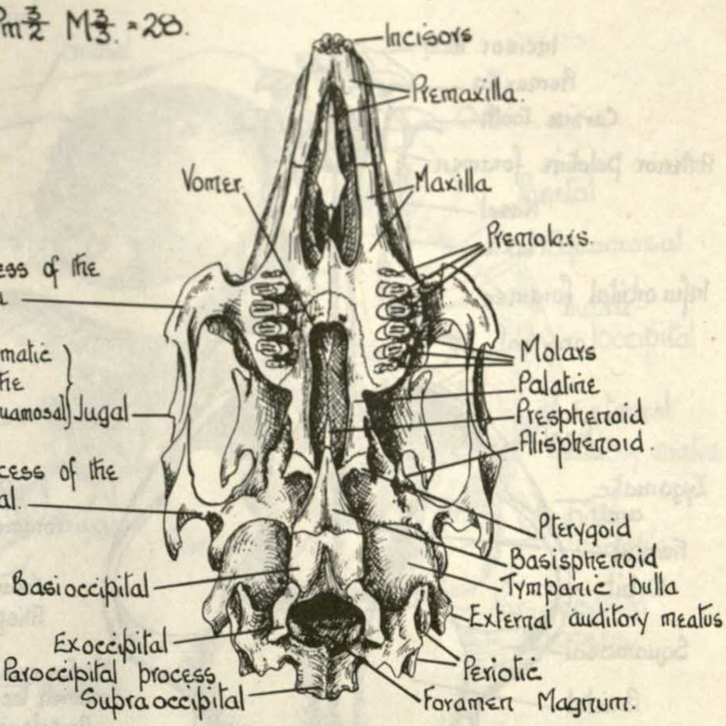
LEPUS CUNICULUS (RABBIT) SKULL AND DENTITION.

Dorsal Surface.

Dentition $I\frac{2}{1}\ C\frac{0}{0}\ Pm\frac{3}{2}\ M\frac{3}{3} = 28$.

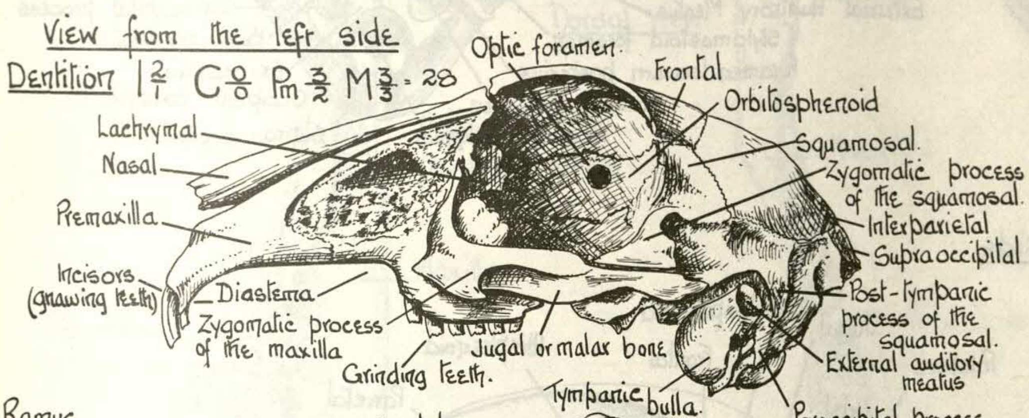


Ventral Surface.



View from the left side

Dentition $I\frac{2}{1}\ C\frac{0}{0}\ Pm\frac{3}{2}\ M\frac{3}{3} = 28$



Ramus
Left half of the lower jaw or Mandible

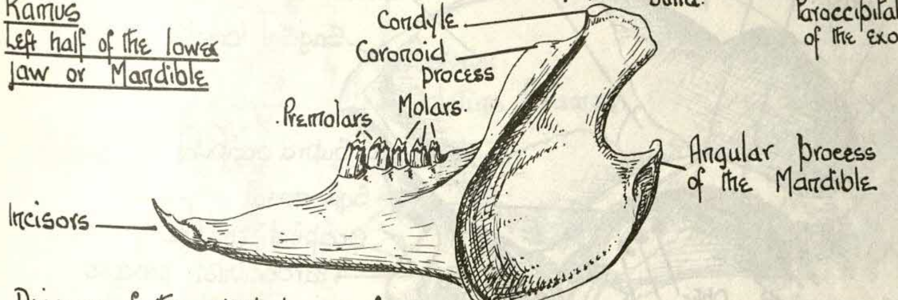


Diagram of the skull bones of a Mammal. (from Borradaile)

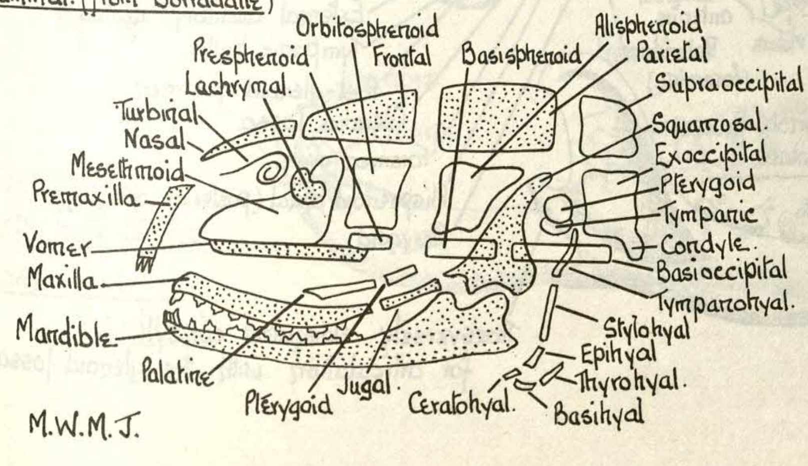
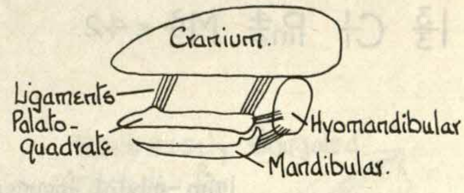
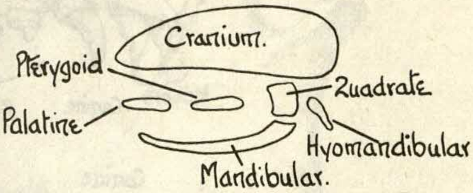


Diagram of the Jaws of Vertebrate Animals (from Borradaile)

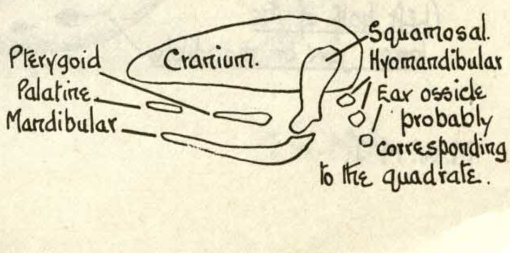
Hyostylic arrangement in Dogfish, where the hyomandibular takes part in the suspension of the lower jar.



Autostylic arrangement in Frog. Here the jaw is suspended by the quadrate (Similar arrangement in Reptiles and Birds.)



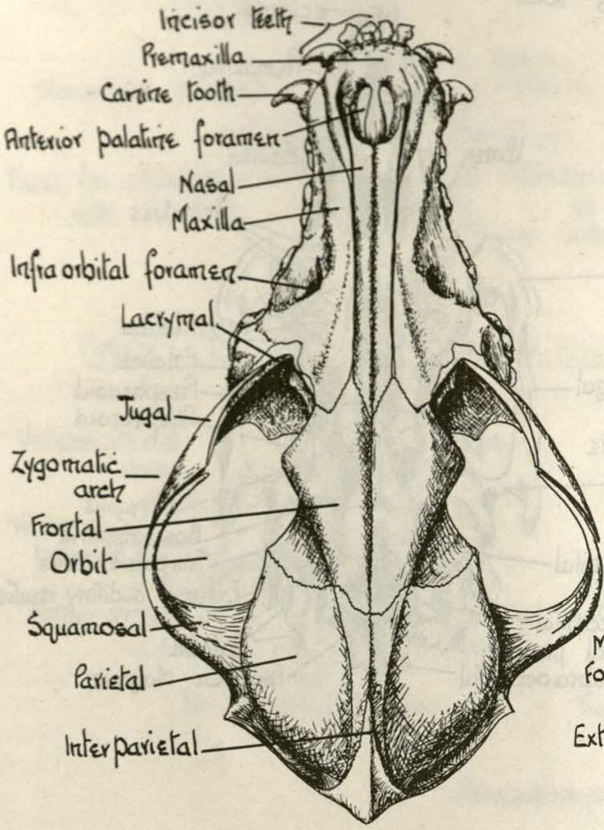
Arrangement in Rabbit where the lower jaw is suspended by the Squamosal.



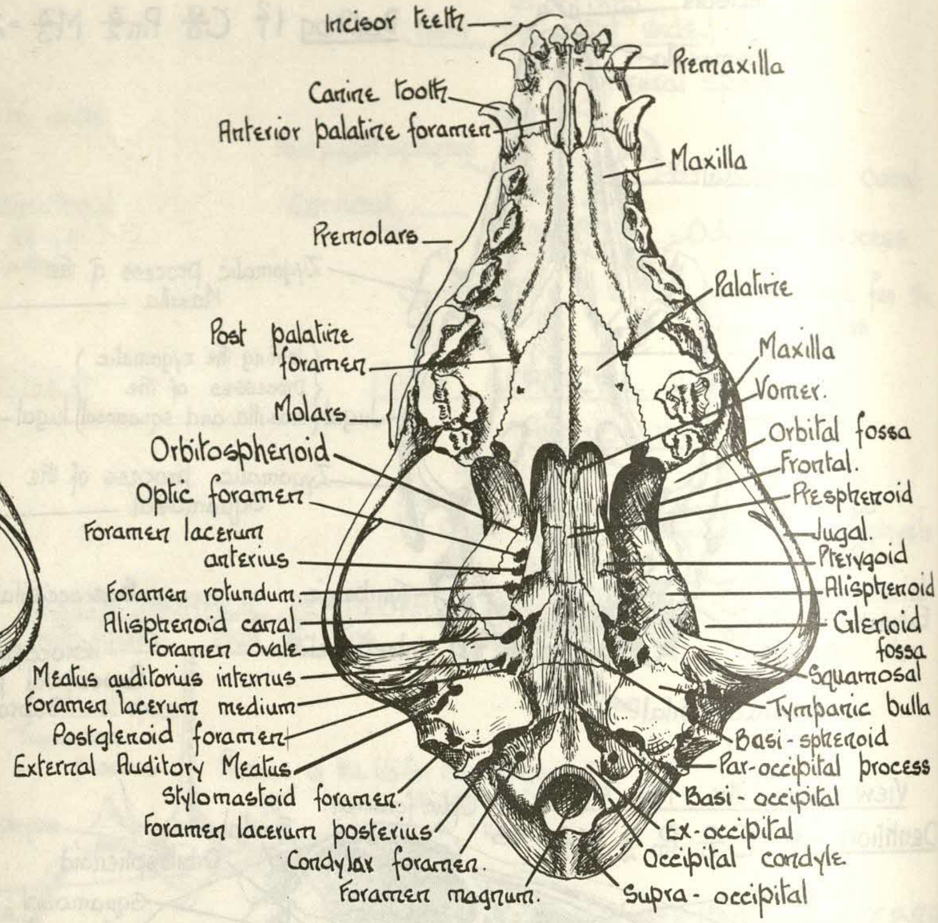
M.W.M.J.

CANIS FAMILIARIS (DOG) SKULL AND DENTITION.

Dorsal Surface



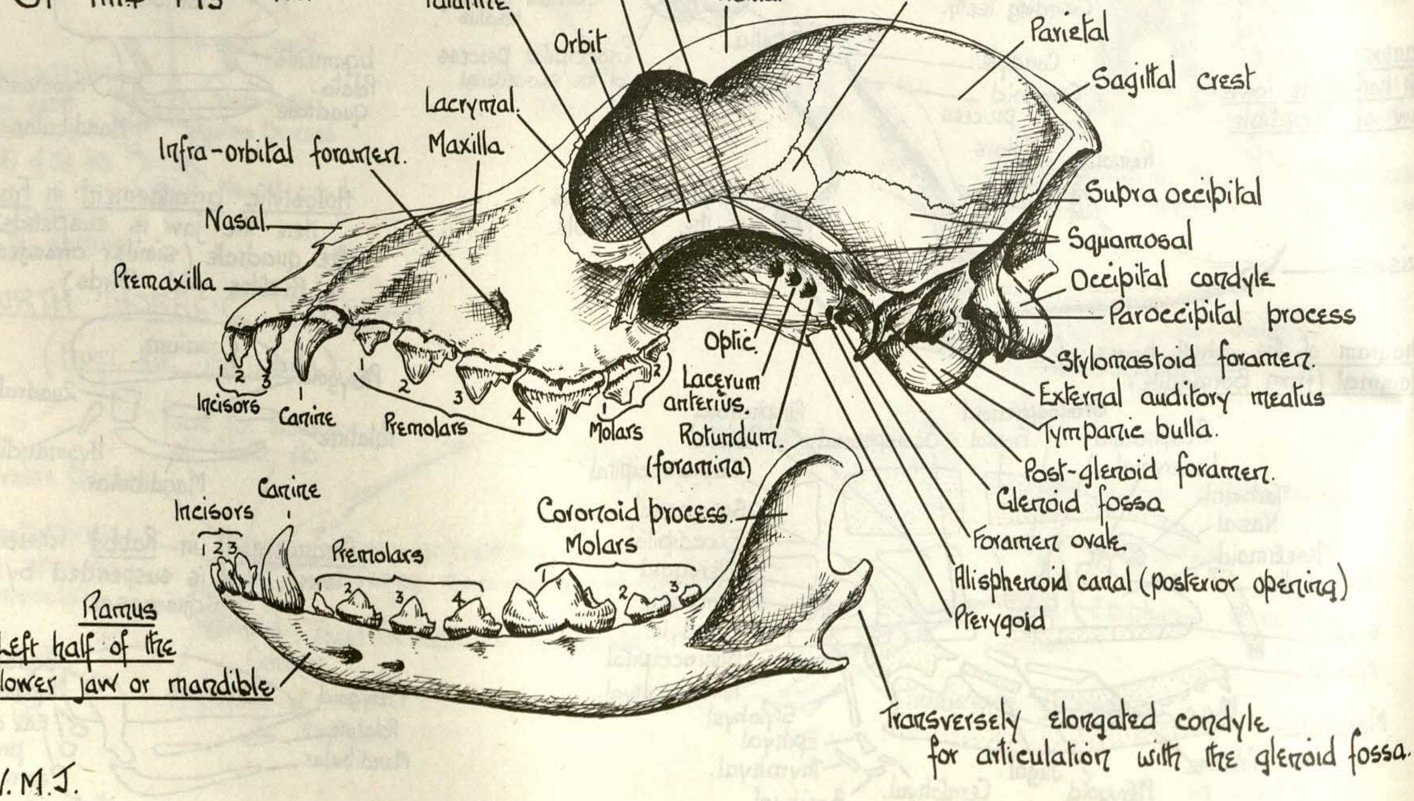
Ventral Surface.



View from the left side

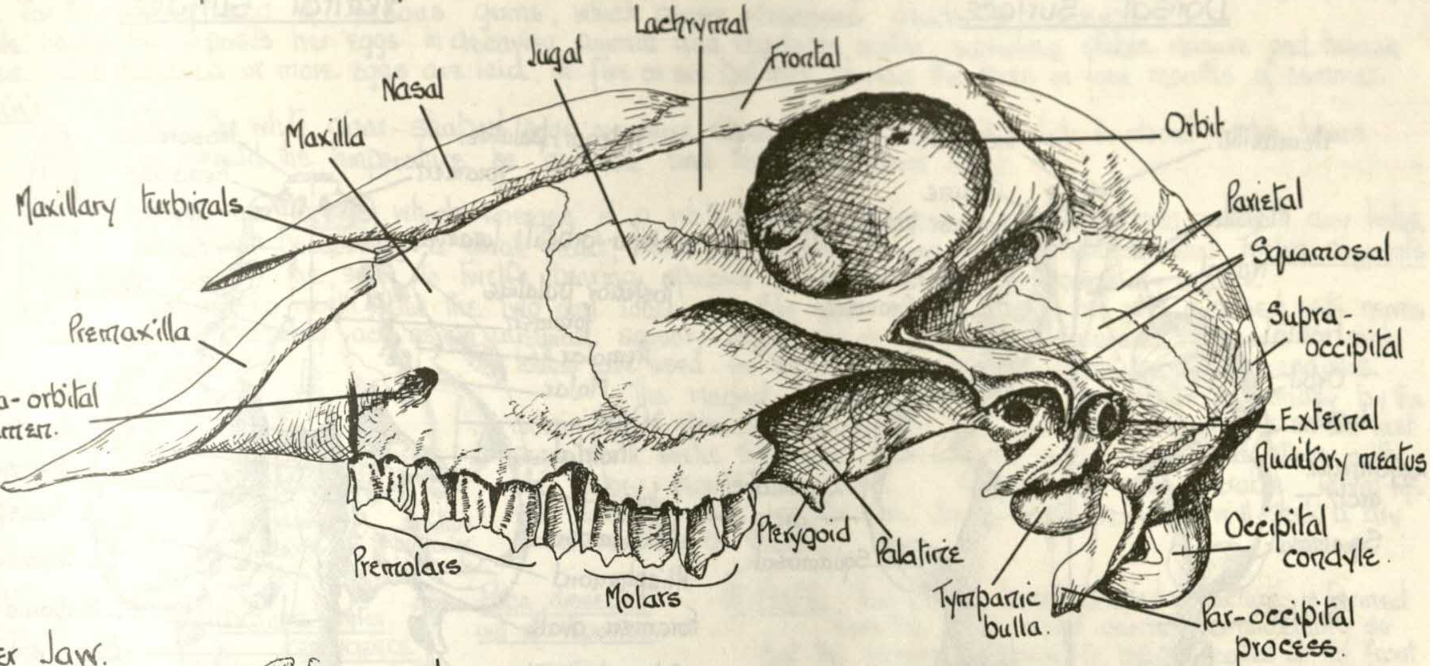
Dentition.

$I\frac{3}{3}\ C\frac{1}{1}\ Pm\frac{4}{4}\ M\frac{2}{3} = 42.$

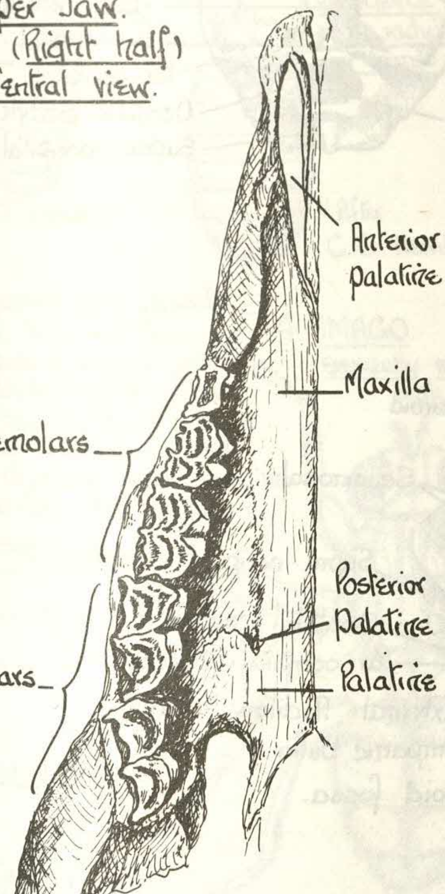


M.W.M.J.

View from the left side.



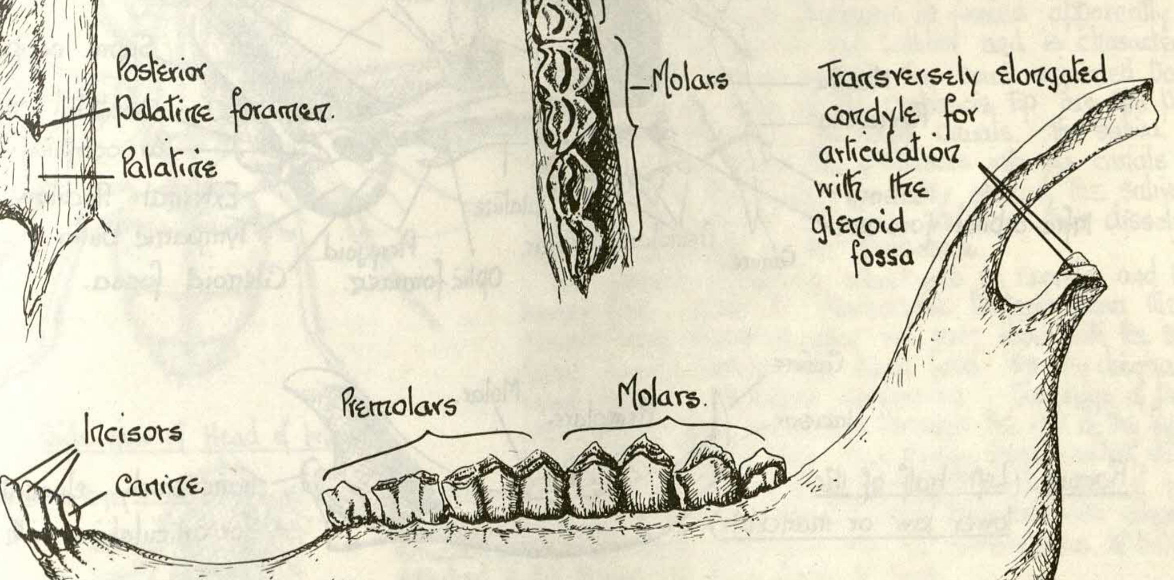
Upper Jaw. (Right half) Ventral view.



Lower Jaw (Right half) Dorsal view.

Dentition

$$I\frac{0}{3}\ C\frac{0}{1}\ Pm\frac{3}{3}\ M\frac{3}{3}$$

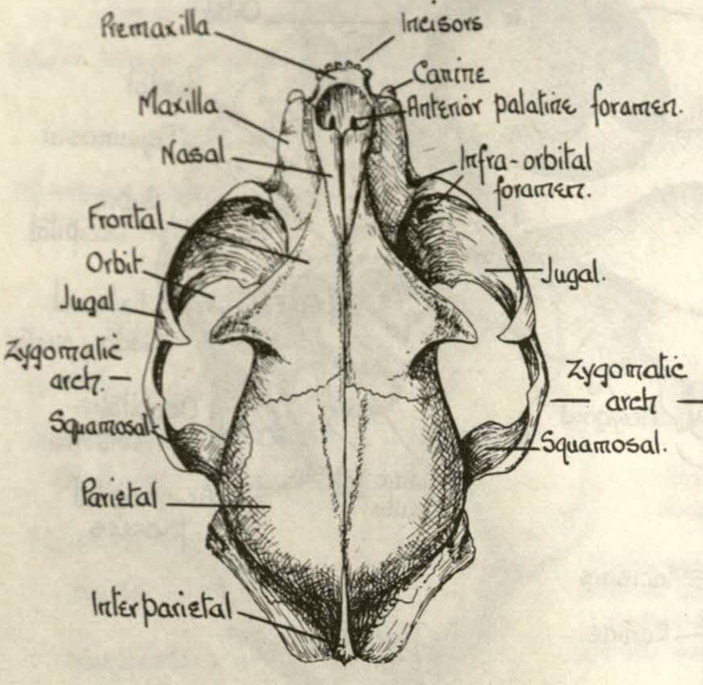


Ramus (Left half of the lower jaw or Mandible)

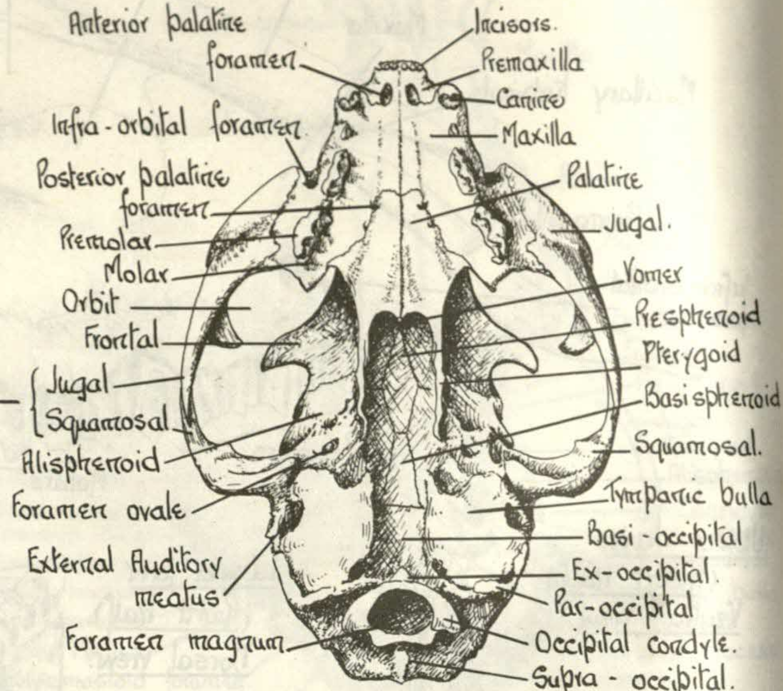
M.W.M.J.

FELIS (CAT). SKULL AND DENTITION

Dorsal surface.



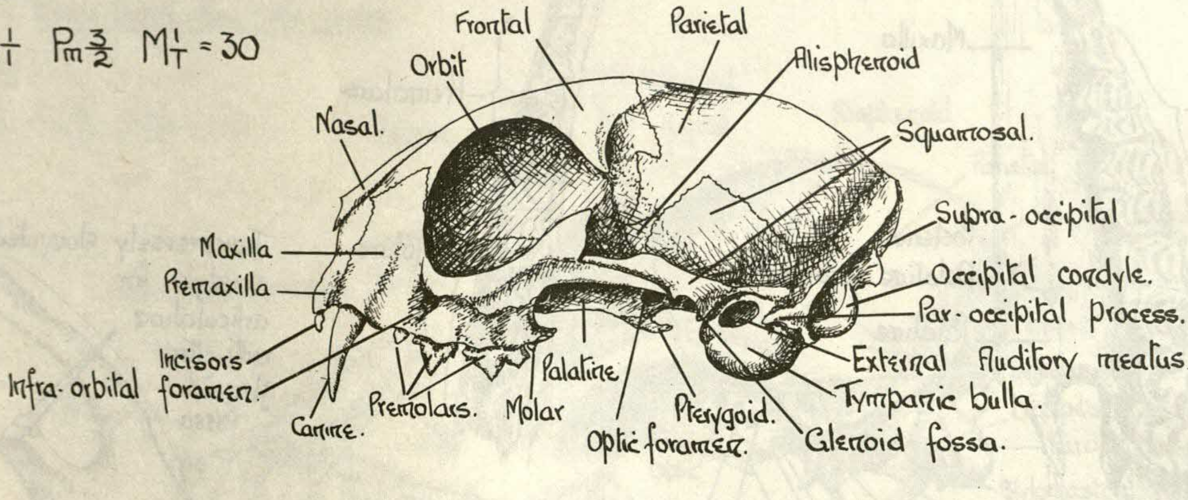
Ventral surface.

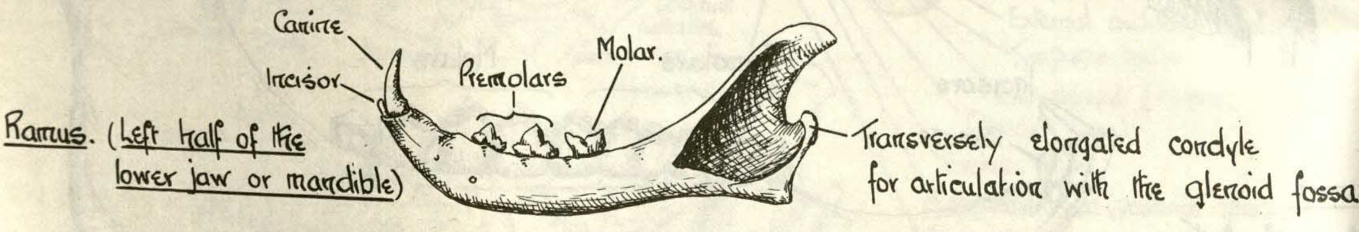


View from the left side.

Dentition.

$I\frac{3}{3}\ \ C\frac{1}{1}\ \ Pm\frac{3}{2}\ \ M\frac{1}{1} = 30$

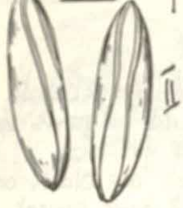




M.W.M.J.

The life history of this insect is of great economic importance, owing to the fact that the fly or imago is responsible for the transmission of various germs, which cause diseases, deadly to mankind.
Female house-fly deposits her eggs in decaying animal and vegetable matter, including stable manure and human faeces. One hundred or more eggs are laid, in five or six batches, during the three or four months of summer.

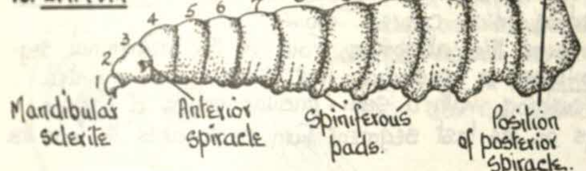
1. EGG.



I EGG. The white cigar-shaped eggs measure about $\frac{1}{25}$" long, and will hatch in about twelve hours should the temperature be suitable and the substratum moist.

II LARVA or Maggot, which emerges is a white segmented creature about $\frac{1}{20}$" long, without any limbs, and possessing a small "head", which is readily drawn in at the anterior end. Twelve segments are visible - the sixth to twelfth bearing spinous pads which act as locomotory organs.
There are no ocelli, but the two oral lobes on either side of the mouth are well supplied with nerves and so probably act as an adequate sensory organ. Black hook-like structures between the oral lobes are used for locomotion and feeding, and represent mandibles.

2. LARVA



The maggot breathes by trachea which open externally by the anterior pair of spiracles on segment two, and the posterior pair on the last segment. It seeks the moist dark places and during this stage in its life-history moults only twice. If conditions are favourable larval life will terminate after about five days, when the larva will seek a dry place in order to pupate.

3. PUPARIUM

Puparium after emergence of the adult or Imago

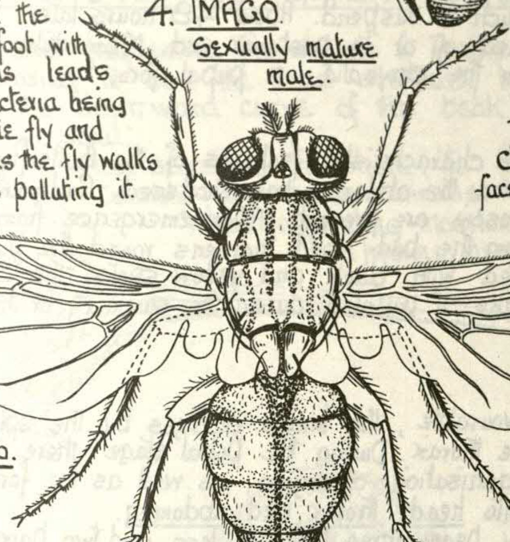
Pupa dissected out of Puparium

(After C.G. Hewitt.)

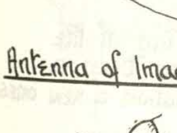
III PUPA. This brown, barrel-shaped structure is formed from the larva which shortens considerably so that the segments appear to be telescoped at the front end. The transformation from larva to pupa takes place without any moult.
During the three or four days of pupal life in the summer, (or through the winter) the internal organs disintegrate and form a jelly-like mass, which gives rise to cells from which new organs are produced.

The general hairy character of the body and the structure of the foot with its glandular pads leads to harmful Bacteria being picked up by the fly and later deposited as the fly walks on our food, thus polluting it.

4. IMAGO
Sexually mature male.



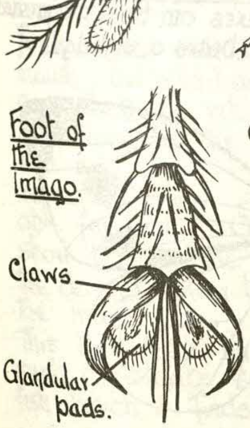
Antenna of Imago.

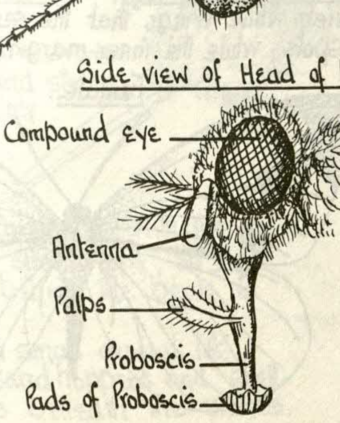


IV IMAGO. When the adult insect or Imago emerges from the pupal case, it does so by lifting off one end by means of a sac protruding from its head. The sac is then withdrawn. On expansion and hardening of the wings, the insect becomes the full grown Imago. Many flies die in the Autumn, but some hibernate through the winter.
The head has two compound eyes and three simple eyes (ocelli). The Maxillae and Mandibles, as such, are not present, while the characteristic antennae which are sunk into the concavity of the face have a flattened outgrowth from the third segment.
The tubular Proboscis is formed apparently from the Labrum and Labium and is characteristic. It bears in front two small unjointed palps, while at the proboscis tip are two pads traversed by small canals. The saliva passes down the proboscis into the canals and so on to the pads. The latter spread the saliva upon the surface of the food which is thus dissolved and then absorbed by the proboscis.
This method of feeding, sometimes on excreta and then human food, leads to pathogenic Bacteria from the excreta being deposited upon our own food with the saliva. Again, during contact with such food the fly discharges liquid faeces, probably containing the eggs of parasites which pass unharmed through the gut of the fly, but on reaching that of man may cause some virulent disease.

Side view of Head of Imago

Foot of the Imago.





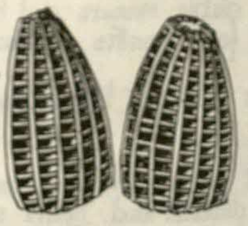
The thorax bears only one pair of wings for flight, and a pair of rudimentary hind wings or Halteres, which, being provided with sensory structures, are probably concerned with the maintenance of balance.
Attached to the thorax are three pairs of legs.
Respiration takes place by trachea which open externally by one pair of thoracic spiracles and seven pairs of abdominal spiracles.
Each leg ends in a five-jointed tarsus, the last joint bearing two claws. Under each claw is a pad covered with hairs. When the pad is pressed, the hairs exude a sticky fluid, which enables the fly to run up slippery surfaces with ease.

M.W.M.J

STAGES IN THE LIFE HISTORY OF THE CABBAGE WHITE BUTTERFLY. (Pieris brassicae)

METAMORPHOSIS is the term applied to a series of abrupt changes which take place in the life-cycle of an organism from the free-living larval form to the adult state.

I. EGG



These egg cases form the first food of the Larva.

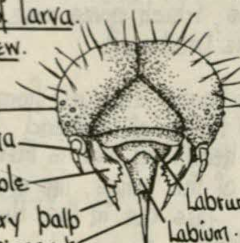
Fertilisation is internal. The yellow eggs are laid in batches of 60–100 in May and August, those laid in late summer being more plentiful. They are small, blunted, conical structures, which are symmetrically ridged and ribbed. They are found in great numbers on the under surface of Cabbage leaves and Nasturtium leaves.

II LARVA.

Leg of larva.

Pro-leg of larva.

Head of larva. Front view.



After hatching the hairy caterpillars keep together for some time, but later separate and feed alone. During the larval period, the animal feeds voraciously and outgrows the skin or cuticle, which it periodically sheds, until it eventually reaches its full size.

The body is yellowish green with raised papillae which are black on the back and brown on the sides, and from which stiff hairs project. Behind the head there are thirteen segments.

The first three thoracic segments following the head bear three pairs of 5-jointed legs, each ending in a curved claw.

The remaining segments form the abdomen. Four of the abdominal segments bear paired pro-legs or "cushion-feet," which are unjointed fleshy protuberances, terminating in a cushion with a semi-circular series of hooks, by which the animal clings. The pro-legs on the last segment turn backwards to form the claspers.

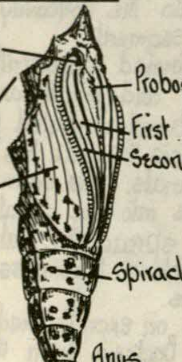
The compound eyes characteristic of the butterfly are represented in the larva by three pairs of simple eyes, or ocelli. The antennae, maxillae and labial palps of the adult are rudimentary, while the mandibles, which are absent from the adult, are here large and strong, biting organs.

Projecting from the labium, or lower lip, is the spinneret by which the products of the paired silk glands are poured out. The silk is a sticky fluid which hardens on exposure to air. By movement of the head from side to side a silk zig-zag ladder is formed as the animal progresses, and it is on to this that the animal clings by means of its pro-legs. Thus it is able to get a firm "foothold" on the most difficult surface.

Respiration takes place by means of trachea, which open to the exterior by spiracles on the first thoracic and first eight abdominal segments.

When fully grown the larva ceases to feed and begins to climb, as described above, in search of a suitable place to pupate. On finding this, it spins a small quantity of silk by which to suspend. About 48 hours later the cuticle splits along the back, and is worked off at its posterior end. Meanwhile the body within shortens and swells, taking on the chrysalid or pupal form.

III CHRYSALIS.



III CHRYSALIS OR PUPA

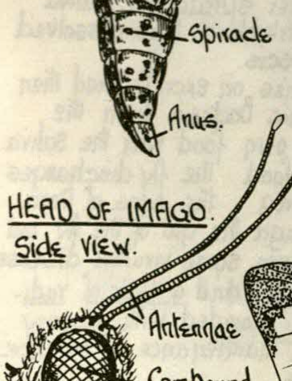
Here the characteristic features of the Butterfly are evident. The mandibles have disappeared and the abdomen has shortened. Rudiments of the wings, compound eyes, antennae and proboscis are present. After emergence from the last larval skin, a chitinous fluid exudes from the body and hardens round the pupa as a yellowish-green "shell" decorated with black and yellow spots. The chrysalis now remains quiescent for 2 or 3 weeks if pupated during the summer, or through the winter if pupated in the Autumn.

IV IMAGO.

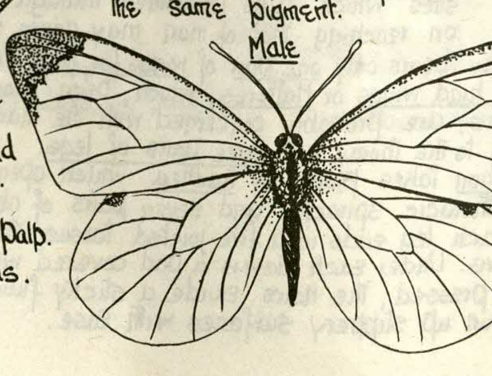
When conditions are favourable, the Imago emerges by the splitting of the pupal skin along the back of the thorax. During the pupal stage there has been a tremendous breakdown and reorganisation of organs, as well as the formation of new ones. The adult insect shows division into head, thorax, and abdomen.

The thorax which is black and hairy bears three pairs of legs, and two pairs of wings. It is by the difference of decoration in the yellowish white wings that the sexes can be distinguished. The front wings of the female bear two black spots, while the inner margin bears a smudge of the same pigment.

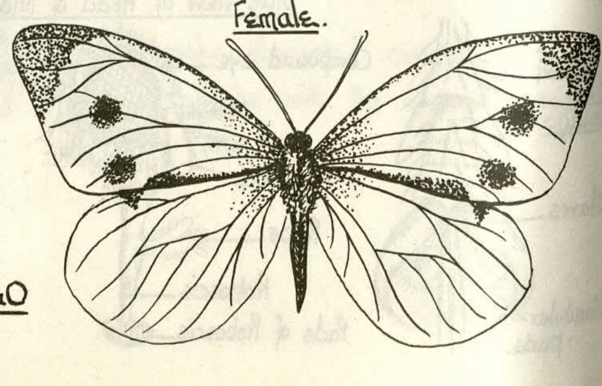
HEAD OF IMAGO. Side view.



Male



Female.



IV IMAGO

M.W.M.J.

BIRDS OF PREY - CARNIVOROUS (Flesh Eaters)

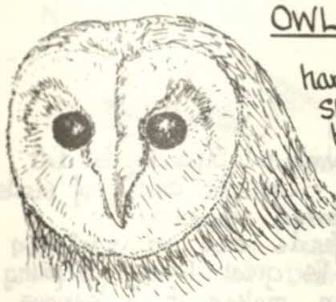
The beak of these birds is particularly adapted to the carnivorous habit. It is short, curved and very sharp, so that the death blow is easily given either by severing the jugular vein or by piercing the skull. In many cases, the feet are also adapted to assist in seizing, carrying, and even dismembering the prey.

MERLIN Tremendous liking for young birds, but also devours insects fish and other small animals.

KEA

A member of the Parrot family, the Kea was originally an insect feeder, but on the introduction of sheep into New Zealand it began to frequent the stations, devouring the offal. Later, it began to attack live sheep. It comes in numbers at night, worry the weaker members to death, afterwards devouring the Kidney fat.

OWL. Most useful in that it feeds on rats, mice, and other harmful Rodents, as well as sparrows. It is chiefly a nocturnal bird, but not entirely so.



FALCON. Feeds mostly on birds, particularly the larger ones such as Wild Duck etc. Very partial to birds which form the food of man. Strikes and kills its prey with its powerful talons.

CROW

Very destructive bird, robbing nests and so causing great loss to breeders of game and poultry.

RAVEN

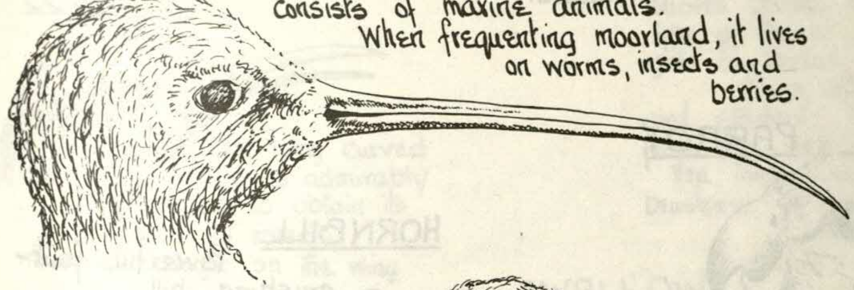
As a scavenger, this bird is very useful. On the other hand it is a troublesome pest in that it attacks sea fowl.

DIET OF WORMS AND OTHER SMALL ANIMAL LIFE.

CURLEW. A bird frequenting the shore. It walks slowly, appearing to bow the head alternately left and right, so that the downward curve of the beak is even with the sand.

When searching the shore, its food consists of marine animals.

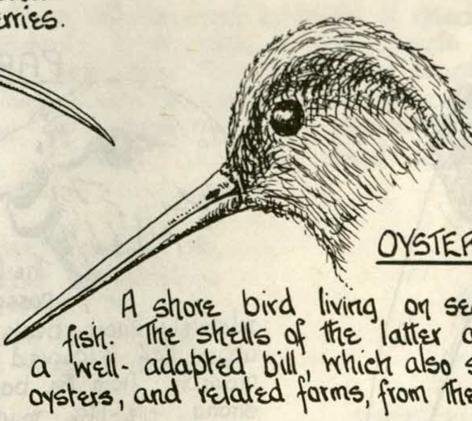
When frequenting moorland, it lives on worms, insects and berries.



KIWI.

A flightless bird. Unique in that the nostrils are at the tip of the beak.

It has extremely poor sight, and feeds chiefly on grubs and berries.



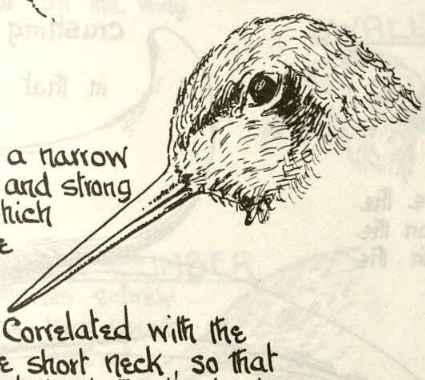
OYSTER CATCHER.

A shore bird living on seaworms and shellfish. The shells of the latter are prized open by a well-adapted bill, which also serves to remove oysters, and related forms, from their firmholds on the rocks.

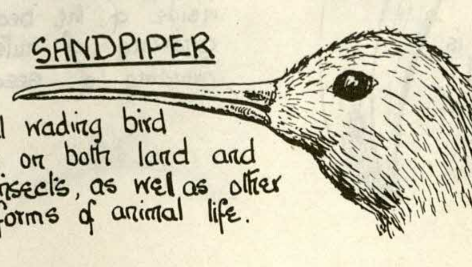
TURNSTONE

A shorebird with a narrow mouth, but short and strong conical beak, which is upturned at the end and so especially suitable for lifting. Correlated with the short beak is the short neck, so that the driving power behind the beak is the maximum.

This bird feeds on small animal life such as shrimps, sandhoppers and shellfish, which it finds beneath the stones.



SANDPIPER



A small wading bird feeding on both land and water insects, as well as other small forms of animal life.

M.W.M.J.

DIET OF SEEDS AND FRUITS

NUTHATCH

This bird is an excellent climber, running both up and down equally well. It is purely a vegetable feeder, and eats in particular, nuts, which it cleverly fixes into a crevice in the bark, splitting them with its strong beak.

The Nuthatch has a preference for Sunflower and Hemp seeds.

NUTCRACKER

A member of the crow tribe and like them will eat animal food. It particularly frequents coniferous forests, where it lives upon pine and fir cones.

BUNTING

The Bunting possesses the short conical beak characteristic of seed-eating birds. It is very partial to corn.

SISKIN

The adult bird feeds mostly on various kinds of seeds and yet it feeds its young entirely on insects.

LARK

Very well adapted to its diet which consists chiefly of seeds swallowed whole. It feeds also on vegetation. Its great liking for young corn makes it a serious nuisance. The lark will also devour insects.

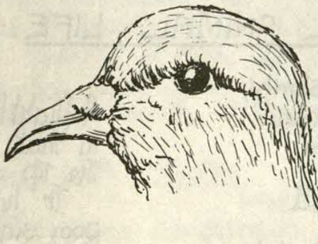
CROSSBILL

The crossed bill enables the bird to pick up the smallest seed with ease. It also prizes open fir cones, a task in which the tongue assists.

BLACKBIRD

Very fond of succulent fruits.

DOVE



Mainly a vegetable feeder, its food consisting of seeds and weeds.

TOUCAN

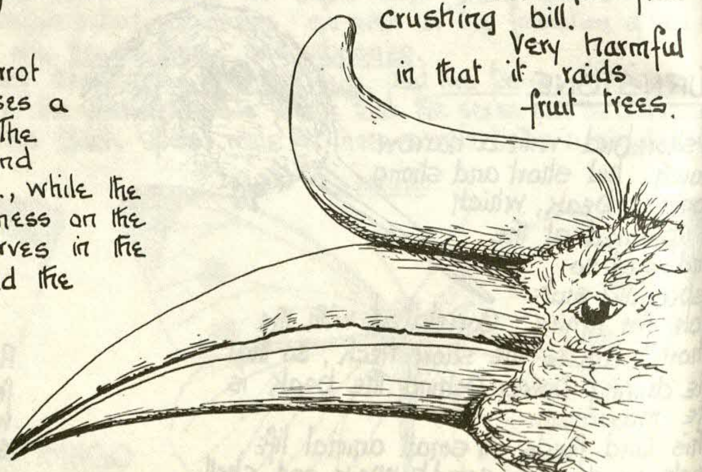
Here the diet consists of succulent fruits. Like that of the Hornbill, the bill is especially adapted for the purpose of fruit-crushing

PARROT

The Parrot possesses a relatively short beak. The upper half is curved and movable from the base, while the strong file-like roughness on the inside of the beak serves in the gnawing of nuts and the grinding of seeds.

HORNBILL

Powerful fruit-crushing bill. Very harmful in that it raids fruit trees.



M.W.M.J.

BIRDS. INSECTIVOROUS (Diet of Insects)

BEE EATER.

This bird siexes bees in its swallow-like flight or awaits its opportunity by the hives.
Its destructiveness to bees is compensated by its ravages among wasps and other insects.

FLYCATCHER.

Here the bird flies out at the insect, catches it, and immediately returns to its perch.
Insects are also caught on the wing, and even nipped from the ground.

NIGHTJAR

A nocturnal bird feeding entirely on insects found at dusk, or caught on the wing.
It is very partial to bees, and devours wasps, which are readily caught by the wide mouth and small beak.

HOOPOE

Diet consists chiefly of insects, as well as other small animal life.
The Hoopoe spends much of its time digging in the ground with its long hard beak, in search of insects.

GREAT TIT

The bill is very short and strong. The food consists chiefly of insects and other small animal life.
Most destructive in its liking for tree buds and fruits like apple and pear.

CUCKOO

A very useful bird in that it feeds on troublesome insects and their caterpillars, particularly the hairy ones.
The stomach is often lined with the hairs from the bodies of its victims

COURSER

The long curved beak is admirably suited to obtain its food of insects, which are caught on the wing

HUMMING BIRD

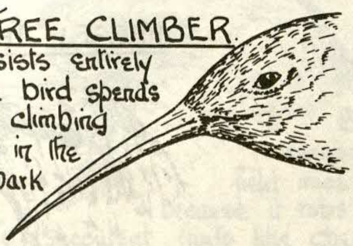
The long slender bill shows perfect adaptation to the type of flower from which the bird gets its nectar.
Much of its food consists of insects and spiders. It will even snatch insects from the web after they have been caught.
The tongue which ends in two delicate brushes is suitable for both nectar-sucking and insect-capture.

SWALLOW

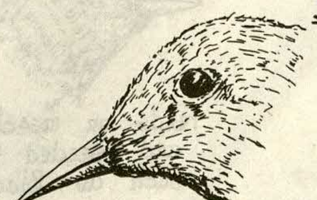
Like the swift, the swallow possesses a very small bill, and captures its food of small insects on the wing.

TREE CLIMBER.

The diet here consists entirely of insects, and the bird spends most of its time climbing trees and looking in the crevices of the bark for its food.



DIPPER



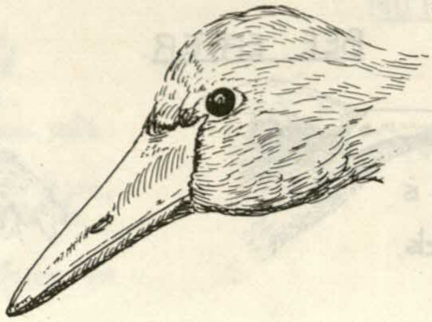
An inhabitant of the shore, this bird dives for its food of water insects.
In addition, the Dipper devours shell-fish.

M.W.M.J.

OMNIVOROUS (Mixed diet of animal and vegetable life)

The Shoveller feeds upon grasses, worms, slugs, snails, insects and small crustaceans.
The ugly bill is a very well adapted sifting organ, being provided with bristle-like structures which retain all edible material as the mud is squeezed through the bill.

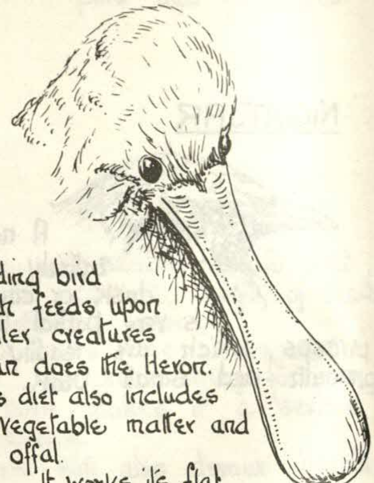
WHOOPER SWAN



Food consists of water plants, grass, small aquatic life, and grain.

SHOVELLER.

SPOONBILL.



A wading bird which feeds upon smaller creatures than does the Heron. Its diet also includes vegetable matter and offal.
It works its flat bill to and fro' in the water, in order to obtain its food.

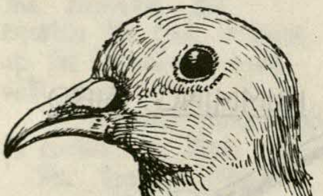
DUCK.

Will devour all kinds of food including worms, small aquatic animals, herbage, berries, acorns and grain.
The inside of the bill is deeply grooved and is well adapted for sifting the mud, and cropping the vegetation.

GOOSE

Purely vegetarian diet includes grasses and marine vegetation. Its liking for grain makes it destructive.

PIGEON.



The beak is soft at the base. Animal diet consists of snails and other small creatures, while the vegetable food includes herbage, seed and grain

STARLING.

Eats almost anything, but works particulary for worms, insects etc, by parting the grass with its long beak. Will also catch insects on the wing, and devour carrion. Frequently climbs trees.

WOODPECKER.

The head is large, and the straight beak is of medium thickness.
It is partial to a diet of nuts and berries. as well as to wood-boring insects, which it easily picks out with its pointed beak
In the insect-eating woodpeckers the tongue bears spines
In the sap-sucking types, the tongue ends in a brush.

HOUSE SPARROW.

Strong seed-cracking beak. Nips insects from the leaves and in the air. Very partial to moths.

CHAFFINCH

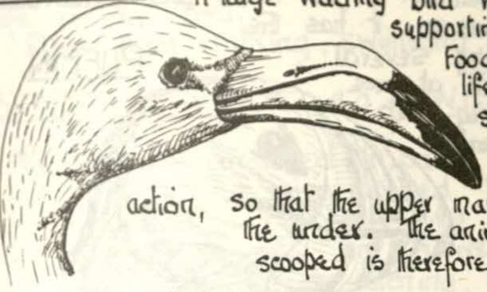
Feeds on insects, buds, and seeded fruits such as Blackberry.

MISSEL THRUSH

Particularly partial to Mistletoe berries and snails

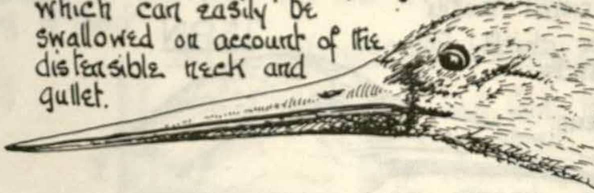
M.W.M.J.

FLAMINGO



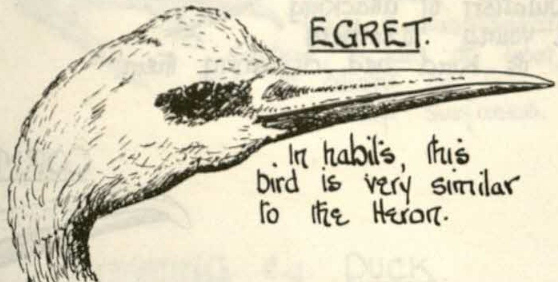
A large wading bird with webbed feet, supporting it in the mud. Food consists of small life, in or at the surface of the mud. The beak is used with a backward action, so that the upper mandible is below the under. The animal matter so scooped is therefore easily captured.

HERON.



A wading bird which can also swim. Eats frogs, fish, young birds and rats etc, which can easily be swallowed on account of the distensible neck and gullet.

EGRET.



In habits, this bird is very similar to the Heron.

PLOVER.

A shore bird, feeding on insects, worms and grubs, as well as ground berries.

PETREL

Feeds on marine organisms. Very partial to scraps of food particularly of an oily or fatty nature. Some of the larger species are reputed to devour the smaller.

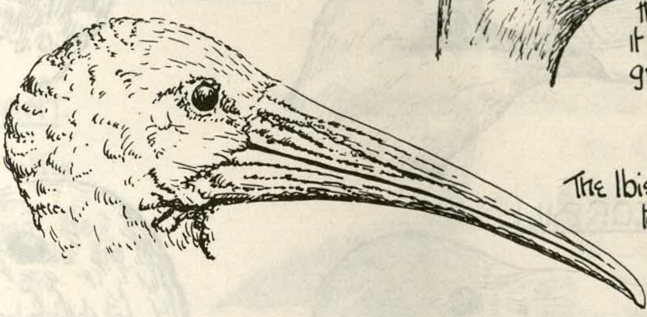
PELICAN.

This bird feeds chiefly on fish which it can store in numbers within the pouch, formed by the lower portion of the beak. The food so stored may be eaten at leisure or carried to the developing young.

COMMON CRANE

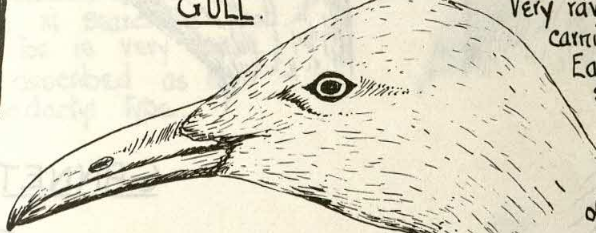
Although a marsh bird the crane is not a fisher. It lives on small animals, grain, and green vegetable food.

AUSTRALIAN IBIS.



The Ibis is a wading bird related to the spoonbills, and resembling them in its feeding habits.

GULL.

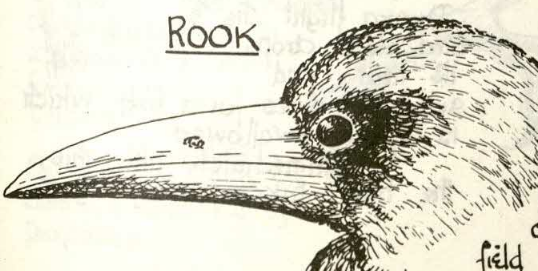


Very ravenous and often carnivorous bird. Eats insects, worms, small fish etc. Benificial as a scavenger and destroyer of injurious insects, it is particularly harmful in its habit of attacking the eggs of other sea fowl.

STORK.

A wading bird, very fond of small animal life and offal. It is very partial to Lizards, snakes, slugs, young birds, small mammals and insects.

ROOK.



Beneficial in devouring carrion, destructive insects, field mice etc. It is harmful because it robs other nests, and is also partial to succulent fruits like cherries, as well as to grain and walnuts.

M. W. M. J.

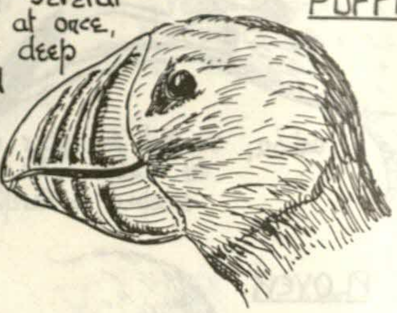
TERN.

Food consists of carrion and animal matter the latter chiefly fish and insects.

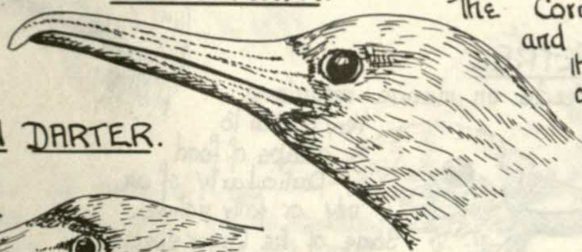
The Tern has the reputation of attacking the young members of its kind and devouring them.

PUFFIN

A diving bird similar to the Auks and Razorbills. Unlike them, however, it has the power of carrying several fish in its beak at once, each time biting deep into the fish and so preventing its escape.



CORMORANT.



The Cormorant swims low in the water, and dives with great power and agility. It feeds on fish, frequently large ones, which it can gorge with great rapidity.

AMERICAN DARTER.

The Darter is a powerful diving bird related to the Cormorants.

GREBE

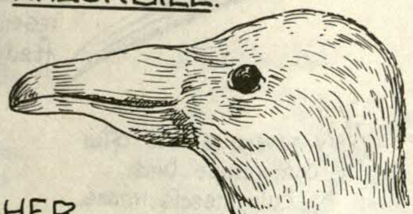
A diving bird, whose food consists chiefly of fish. It is also partial to other aquatic creatures found at or near to the surface of the water.

AUK.

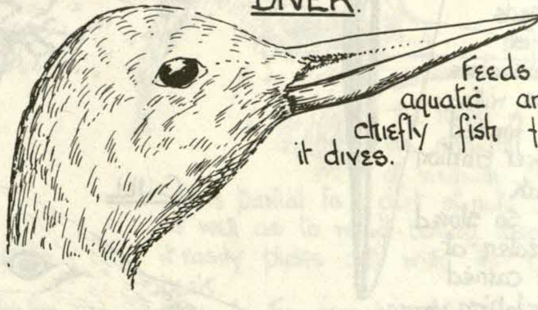
Auks and Razorbills are similar in that they dive for their marine food, which consists chiefly of fish.

Unlike the puffins, the Auks and Razorbills can carry only one fish in the bill at one time.

RAZORBILL.



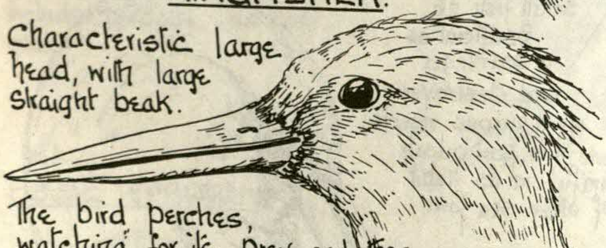
DIVER.



Feeds on aquatic animals, chiefly fish for which it dives.

KINGFISHER.

Characteristic large head, with large straight beak.



The bird perches, watching for its prey, and then darts for, and swallows it whole.

Food consists chiefly of fish, and other aquatic animals.

GANNET.

During flight the bird stops, drops its head, and suddenly dives for a fish, which is rapidly swallowed. Immediately after this, the bird takes wing again.

GOOSANDER.

A very greedy eater of fish, which it devours in great numbers. The Goosander cannot, however, tackle very large fish.

M.W.M.J.

BIRDS. VARIOUS TYPES OF FEET.

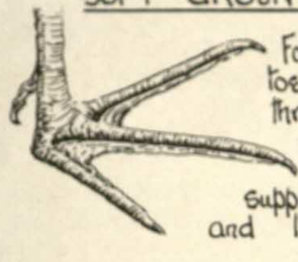
The feet of Birds, like their beaks, show every adaptation to the habitat and mode of life of the Bird.

Apart from walking, swimming, perching and climbing, the feet often aid the beak in the catching and devouring of food.

BIRDS OF PREY. e.g. OWL.

The toes are arranged in pairs, the fourth being directed backwards beside the first, so forming an effective weapon for catching, crushing, and carrying its victims. The talons are sharp and powerful tearing organs. These characteristics, coupled with the hooked beak, are found in all birds of prey.

SOFT GROUND. e.g. CURLEW.



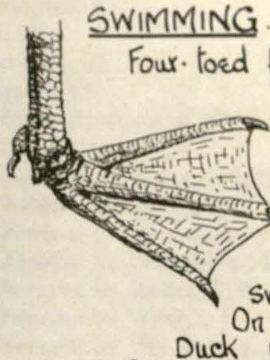
Four-toed foot. Hind toe very small. The three remaining toes are spread out to form a substantial support, to take off from, and to alight on to soft surfaces.

PERCHING e.g. KINGFISHER

Four-toed bird. Hind toe directed backwards, while the three remaining toes are directed forwards, and joined in front for some part of their length.

This foot is an example of the Syndactyl type.

SWIMMING. e.g. DUCK.



Four-toed foot. Hind toe useless. The three toes are fully webbed, a tough membrane being stretched between them.

The foot serves as an effective paddle when swimming

On the other hand the Duck is an ungainly walker.

In Cormorants all four toes are webbed.

RUNNING e.g. PHEASANT.

Similar to the feet of other game birds and fowls.

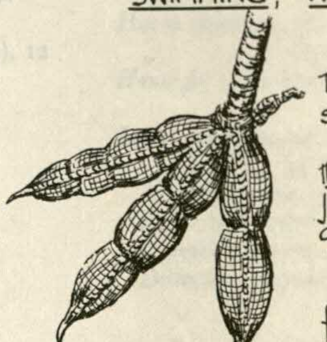
The shanks are strong the feet powerful, while the blunt claws are especially adapted to scratching the ground in search of food.

The hind toe is very small.

This form of foot is described as the Anisodactyl type.

SWIMMING, WALKING AND RUNNING.

e.g. COOT.



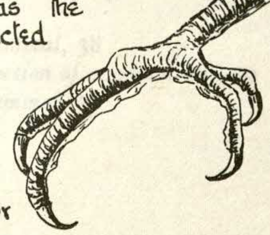
This foot is adapted equally well for swimming, walking and running.

The hind toe is small, while the three front toes are not webbed jointly, but each toe is provided with a scalloped fringe of skin

Thus each toe is webbed separately for swimming.

They are all free to enable the animal to walk easily, and they are widespread to distribute the weight of the body evenly when the bird is walking over boggy areas.

CLIMBING e.g. PARROT.



Zygodactyl type in which the paired toed foot, has the 1st and 4th toes directed backwards, and the 2nd and 3rd toes forwards when perching.

In addition the feet are used for climbing and eating purposes.

Folded position of the foot, where the toes lie behind each other.

Thus in the forward stroke through the water, the foot offers little resistance.

M.W.M.J.

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Printed and Bound in Hong Kong by Wing King Tong Co. Ltd.
and published by John Murray (Publishers), Ltd.

BIOLOGICAL DRAWINGS

WITH NOTES

By MAUD JEPSON, M.Sc. (Manchester)

(First Class Honours in Zoology)

With a Preface by

H. GRAHAM CANNON, M.A., Sc.D., F.R.S.

Formerly Professor of Zoology, The University, Manchester

PART II

LONDON

JOHN MURRAY, ALBEMARLE STREET, W.

To the Memory of my Mother

EMILYNE MAUD JEPSON

First Edition 1938

Twenty-nineth impression 1982

0 7195 0727 8

PREFACE

THE considerable experience gained by Miss Jepson in teaching School Certificate pupils and candidates for higher examinations, has prompted her to produce this book of illustrations. Her object has been, not to minimize or cut out much of the practical work, but rather to enable the student to derive the greatest benefit from a period in the laboratory, which is always too short in the average school curriculum, and usually so even in the University. In both Botany and Zoology the execution of practical work is often long and difficult, but the time taken can be cut down, and the value derived from the dissection or preparation increased enormously when the student, by the aid of a well-labelled drawing, can see what to look for. Miss Jepson's work collects together, in a convenient form, actual drawings of her own preparations, which are realistic and not diagrammatic.

A criticism often levelled against the production of such drawings is that it provides the lazy pupil with something that can be copied, and the actual dissection maybe done not at all. This is admittedly so, but pupils of that level will always be with us, from the preparatory school up to the post-graduate. They cannot and should not be considered. In any case, these drawings of Miss Jepson's, taken as they are from actual dissections, would be difficult to memorize. They are not diagrams which can be remembered easily in a perfectly unintelligent manner. They provide simple drawings which the good student can have by him when he is carrying out his practical work, and by their excellence, provide him with a clear-cut key to the structures and arrangements he is expected to find in his practical work.

H. GRAHAM CANNON.

ACKNOWLEDGMENTS

THE completion of this work would not have been possible, had it not been for the kindness which I have received from many people.

My thanks are due to my friend Miss Elsie I. MacGill, M.Sc., and to my former Lecturer, Mr. W. O. Howarth, D.Sc., both of the Manchester University, for the time which they have so generously given in going through the first rough sketches, and later the finished drawings. Their suggestions and criticisms have been most valuable in the arrangement of this work.

I wish to thank Professor Graham Cannon, Sc.D., F.R.S., for writing the Preface, and also for the kindness he has shown, and the encouragement he has given me, in his criticism of the drawings.

I should like to record my indebtedness to Mr. Heasman, H.M.I., and Mr. Painter, H.M.I., for their helpful suggestions with regard to the publication of these volumes.

I express my gratitude to the Head Master, Mr. M. J. H. Cooke, M.Sc., in whose laboratory much preparation and practical work has been done, and to Mr. George Wood, M.Sc., Principal of the Stockport College for Further Education, whose interest in my drawing and teaching of the subject has been the source of constant encouragement, and also to Mr. Kendell for much advice with regard to the reproduction of such work.

Finally, I should like to thank the publishers for their courtesy and consideration at all times.

MAUD JEPSON.

May, 1938

For whatever improvements are to be found in this second edition I must again thank Miss Elsie I. MacGill and Dr. W. O. Howarth.

To Professor Graham Cannon I am much indebted for his valuable help and advice.

MAUD JEPSON.

February, 1939

ENTOMOPHILY - INSECT POLLINATION.

Pollinating Agents.

From the point of view of pollination, the classification of insects, is based upon the length of the sucking tongue or proboscis

Moths and Butterflies have a very long proboscis, so that they rarely alight on the flower, while seeking nectar. The flowers have no alighting platform, and the essential organs protrude.

Moths are night-flying and are attracted particularly by yellow flowers, which usually emit a strong perfume at night. e.g. Honeysuckle, Evening Primrose etc.

Butterflies most frequently visit red and white flowers. e.g. Pinks.

Bees and Wasps have a fairly long proboscis, are relatively heavy insects, and therefore always alight on to the flower. The latter is provided with an alighting platform.

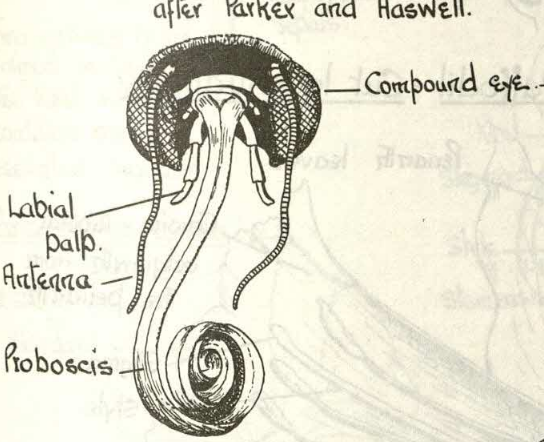
Bees appear to be particularly fond of blue flowers. e.g. Monkshood.

Wasps have a preference for bronze colours. e.g. Figwort.

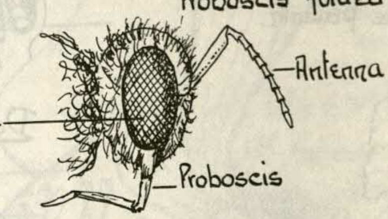
Flies These have a very short proboscis, and visit large open flowers, small tubular flowers, as well as many capitula, corymbs and umbels. They are attracted by dirty colour and foetid odour e.g. Hemlock, while some flowers are especially adapted for pollination by flies. e.g. Wild Arum.

Beetles These insects do not possess a proboscis, but visit open flowers, capitula etc probably effecting pollination during their wanderings. e.g. Sunflower.

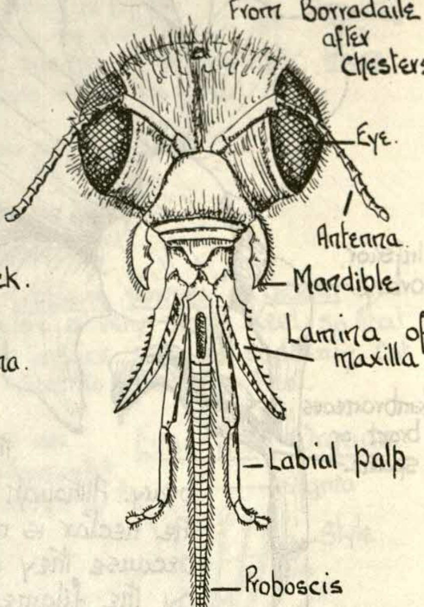
MOTH. Head. Front view
after Parker and Haswell.



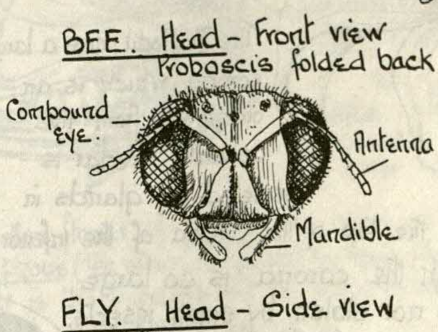
BEE. Head - Side view.
Proboscis folded back



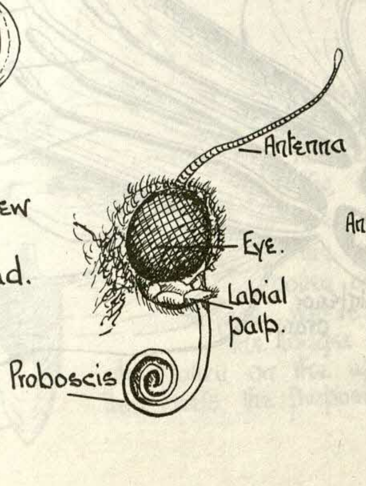
BEE. Head - Front view.
Proboscis extended.
From Borradaile after Chesters.



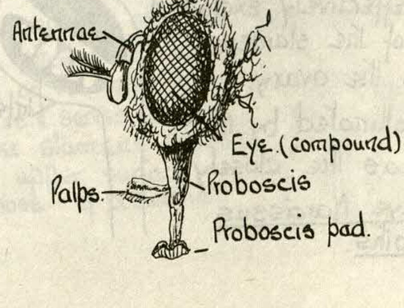
BEE. Head - Front view
Proboscis folded back.



BUTTERFLY.
Head - Side view
Proboscis coiled beneath the head.



FLY. Head - Side view



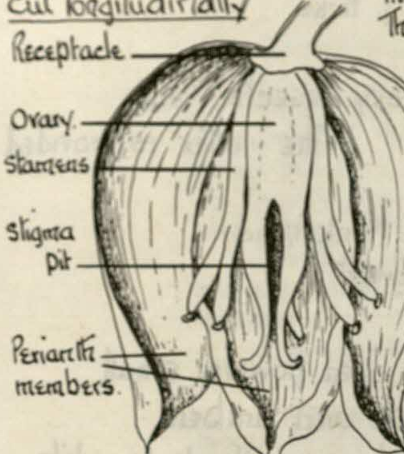
M. W. M. J.

INSECT POLLINATION - SPECIAL ADAPTATIONS

A general survey of entomophilous flowers indicates that as the structure of the flower becomes more elaborate in adaptation to pollination by some particular agent, the more certain is the pollinating process.

On the other hand, such flowers are limited with regard to "choice" of insect visitors, while the less modified and open flowers such as rose are likely to be pollinated by any one of the usual agents.

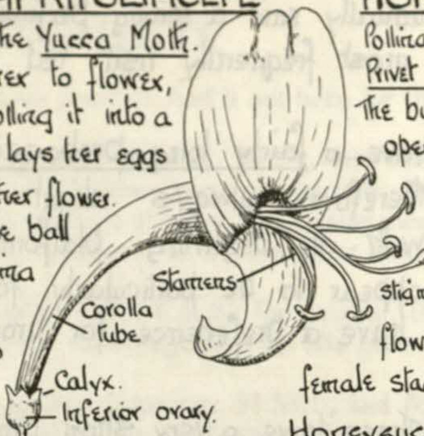
LILIACEAE - YUCCA



This flower is pollinated by the Yucca Moth. The female flies from flower to flower, gathering pollen and rolling it into a huge ball. Finally, she lays her eggs in the ovary of another flower and then deposits the ball of pollen on to the stigma of the same flower, pressing it firmly into the pit.

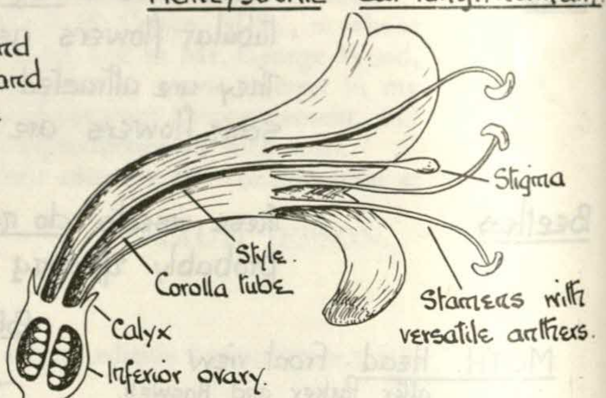
This association of flower and moth might be regarded as symbiotic, because on the one hand fertilisation of the ovules is certain, and on the other, ample food is provided for the developing larvae.

CAPRIFOLIACEAE HONEYSUCKLE

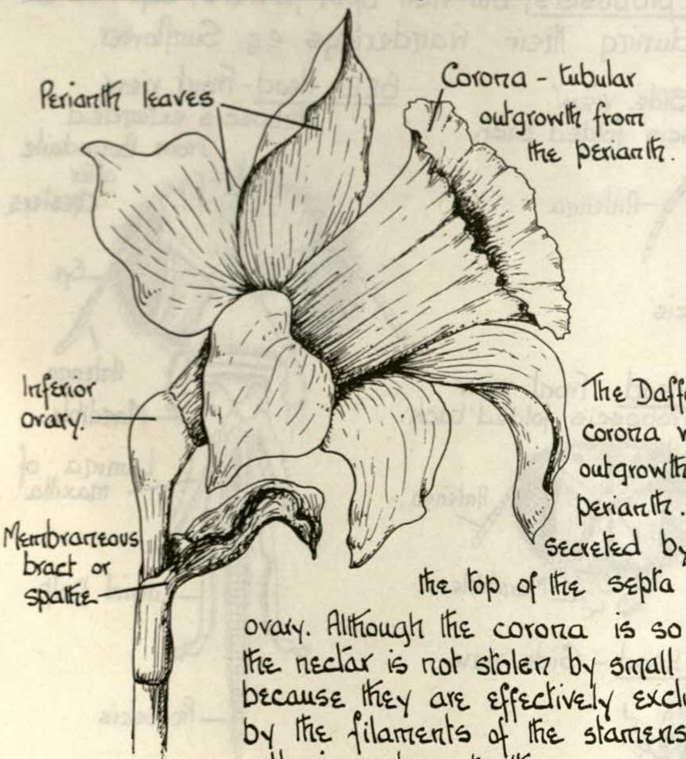


Pollinated by the long-tongued Privet Hawk moth. The buds are erect, and first open at night. They gradually assume the characteristic horizontal position. It is protandrous and in the male stage the flower is pale, but in the later female stage the colour deepens.

Honeysuckle - Cut longitudinally



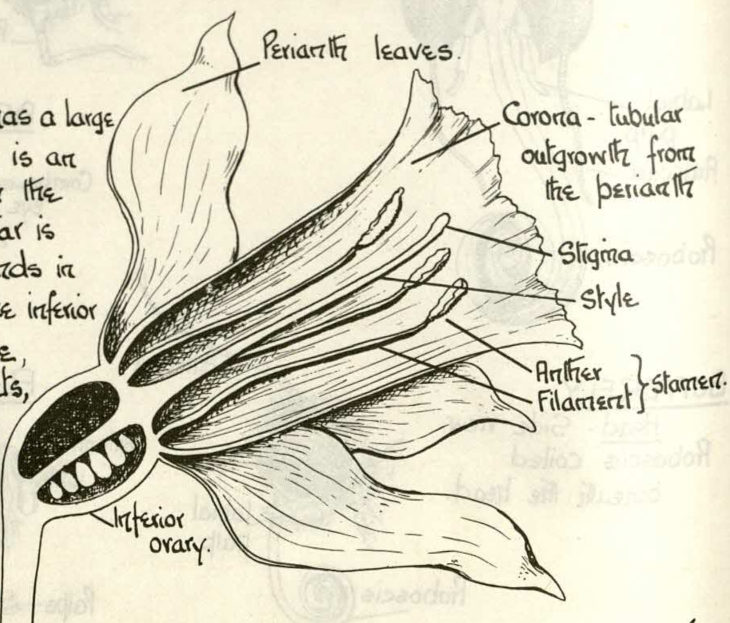
AMARYLLIDACEAE - DAFFODIL



The Daffodil has a large corona which is an outgrowth from the perianth. Nectar is secreted by glands in the top of the septa of the inferior ovary. Although the corona is so large, the nectar is not stolen by small insects, because they are effectively excluded by the filaments of the stamens adhering close to the ovary.

This flower is pollinated by the Humble-bee, whereas the closely related Pheasant-eye Narcissus is pollinated by Moths.

Daffodil - Cut longitudinally



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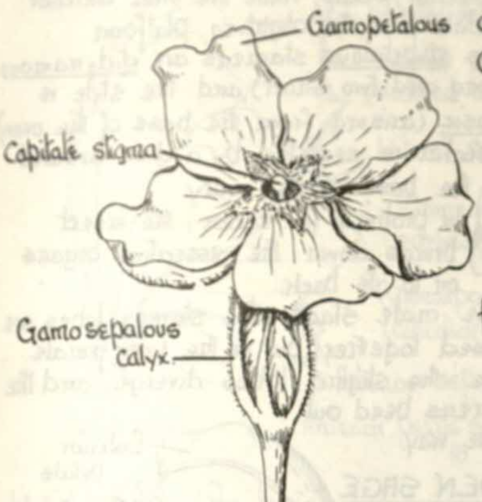
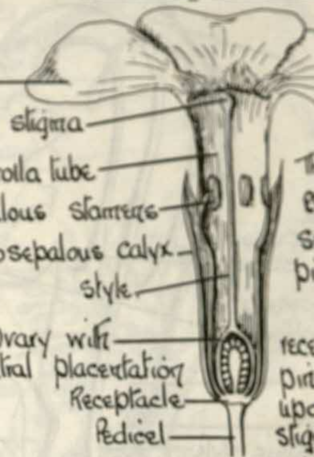
INSECT POLLINATION - SPECIAL ADAPTATIONS.

PRIMULACEAE - PRIMROSE

External Features.



Pin-eyed Type. Cut longitudinally

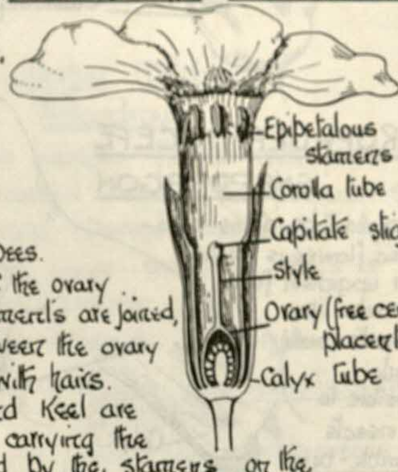


Here two different types of flowers are produced, the difference being in the relative lengths of the essential organs - a special device known as Heterostyly.

Nectar is secreted around the base of the ovary. The larger pollen grains, received from the thrum-eyed by the base of the proboscis, will be at a suitable level for effecting the pollination of the pin-eyed stigma.

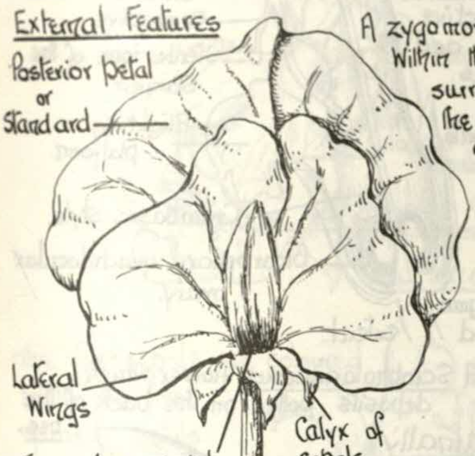
On the other hand, the smaller pollen grains, received by the middle of the proboscis from the pin-eyed, will be at a suitable level for depositing upon the stigma of the next thrum-eyed, visited by the bee.

Thrum-eyed Type - Cut longitudinally



LEGUMINOSAE - SWEET PEA

External Features

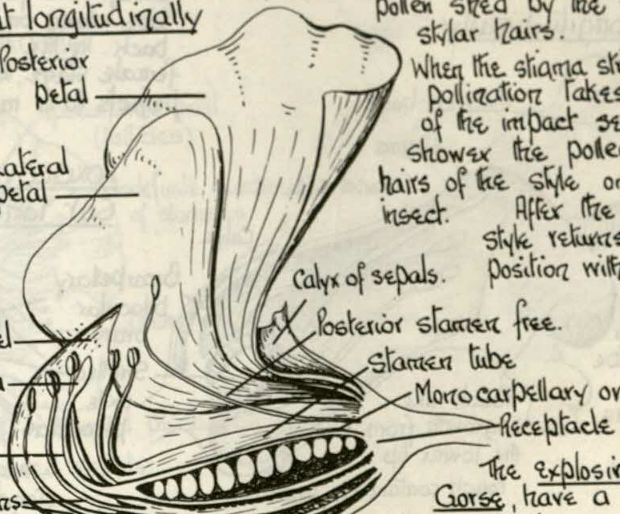


Two anterior petals joined to form the Keel, which contains the essential organs.

A zygomorphic perigynous flower, pollinated by humble bees. Within the Keel are the essential organs, consisting of the ovary, surrounded by ten diadelphous stamens (nine filaments are joined, the posterior one being free). Nectar is found between the ovary and the stamens, while the style is provided with hairs. When the insect alights, the lateral wings and Keel are depressed and the style alone emerges, carrying the pollen shed by the stamens on the stylar hairs.

When the stigma strikes the insect's under surface pollination takes place, while the force of the impact serves to shower the pollen from the hairs of the style on to the insect. After the visit, the style returns to its former position within the Keel.

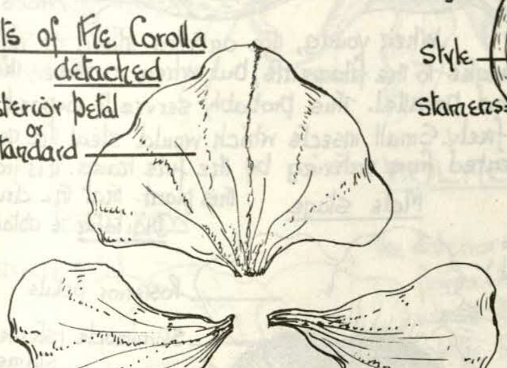
Cut longitudinally



Sweet Pea Style showing the hairs

The explosive flowers of Broom and Gorse, have a very small Keel, so that the essential organs jerk out suddenly, but never return to within the Keel.

Parts of the Corolla detached



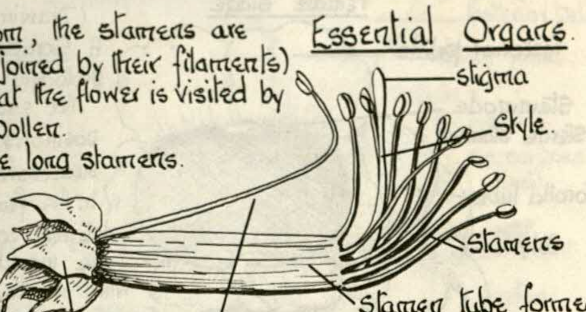
Anterior petals joined along the anterior edges to form the Keel.

M.W.M.J.

In the pollen flower of Broom, the stamens are monadelphous (ten stamens joined by their filaments). No nectar is produced, so that the flower is visited by the insect solely for its pollen.

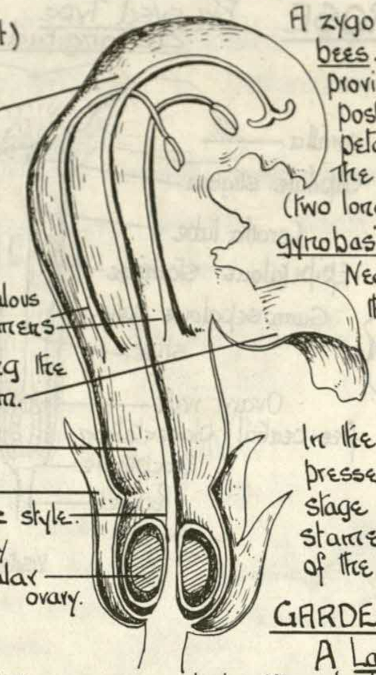
There are five short and five long stamens. The short ones deposit pollen on the insect's under surface, where it serves as food. The longer stamens deposit the pollen on the upper surface. This meets the purpose of pollination.

Essential Organs.



INSECT POLLINATION - SPECIAL ADAPTATIONS.

LABIATAE. - Protandrous (stamens ripening first)



A zygomorphic flower, pollinated by Humble-bees. The longer or shorter corolla tube is provided with a hood formed from the two posterior petals, while the three anterior petals form the alighting platform.

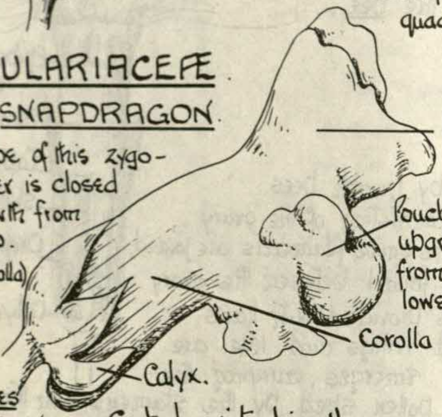
The epipetalous stamens are didynamous (two long and two short), and the style is gynobasic (arising from the base of the ovary). Nectar is secreted by a disc around the base of the ovary.

In probing for nectar, the insect brings down the essential organs on to its back.

In the male stage the stigma lobes are pressed together, but in the later female stage the stigma lobes diverge, and the stamens bend out of the way.

SCROPHULARIACEAE

SNAPDRAGON.

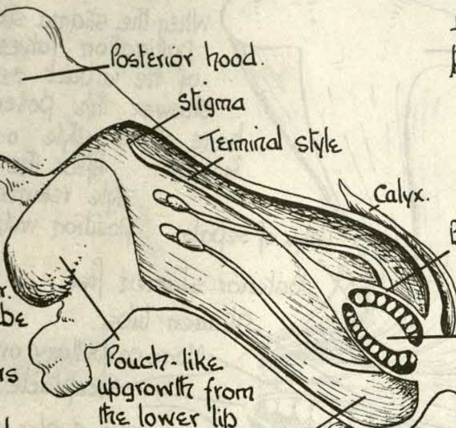


The corolla tube of this zygomorphic flower is closed by an upgrowth from the lower lip. (Personate corolla) It is only accessible to such insects as Humble-bees which are heavy enough to open the tube.

The stamens are didynamous, but unlike the Labiates, the bicarpellary ovary is bilocular and there is a terminal style. The anterior side of the corolla tube is swollen to store nectar.

The construction of the tube is responsible for the fact that the stigmas and anthers move in quick succession against the pollinating agent.

Cut longitudinally



GARDEN SAGE

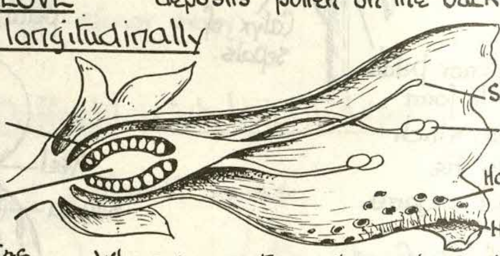
A Labiate, but with only two stamens. Each stamen has a long connective joining the sterile and fertile anther lobes.

The bee probing for nectar comes into contact with the sterile lobe, and brings the fertile lobe down on its back. In the later female stage, the stigma projects to a marked extent.

FOXGLOVE

Cut longitudinally

A Scrophulariaceous flower which deposits pollen on the back of the bee.



When young, the anthers stand at right-angles to the filaments, but when mature, they stand parallel. This probably serves to deposit the pollen more freely. Small insects which would steal the nectar are prevented from entering by the fine hairs. It is from this plant that the drug Digitalin is obtained.

FIGWORT.

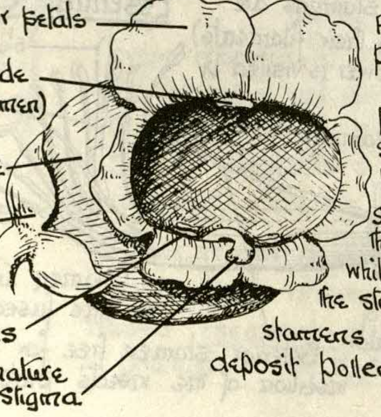
(Drawings much enlarged)

A Scrophulariaceous flower which is protogynous. (Gynaeceum ripening first)

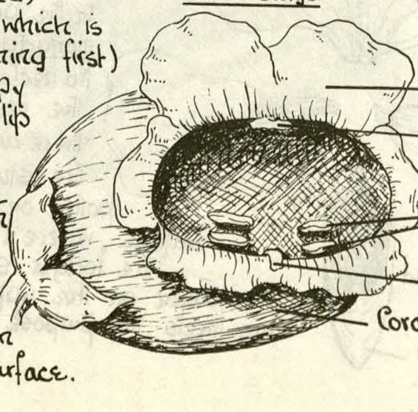
The essential organs occupy positions against the lower lip successively.

In the female stage the ripe stigma comes into contact with the insects' under surface, while in the later male stage the stigma withers, and the stamens occupying a similar position deposit pollen on the Wasp's ventral surface.

Female stage



Male stage



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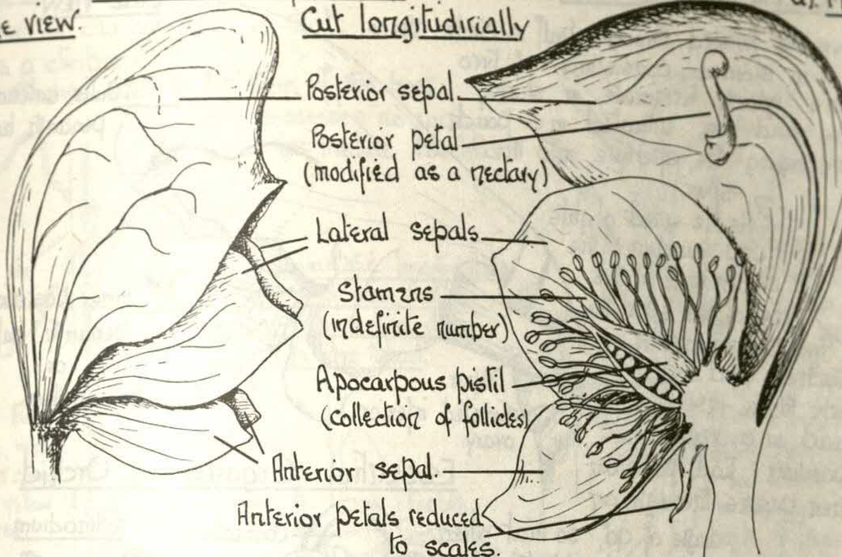
INSECT POLLINATION - SPECIAL ADAPTATIONS.

RANUNCULACEÆ.



a). Monkshood (Aconitum.)

Protandrous (stamens ripen first)

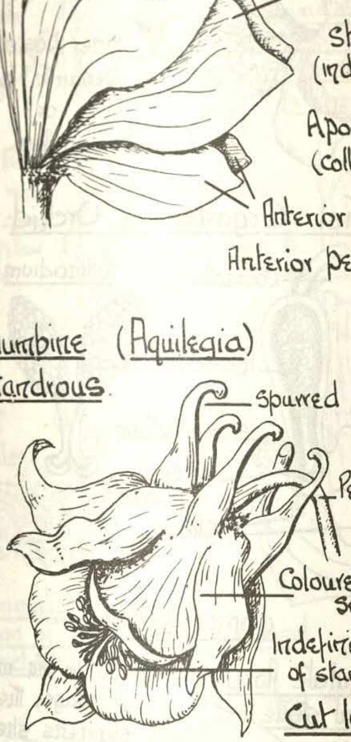
An irregular hypogynous flower with five coloured sepals. The two posterior petals are modified as nectaries, while the three anterior petals are reduced to scales.

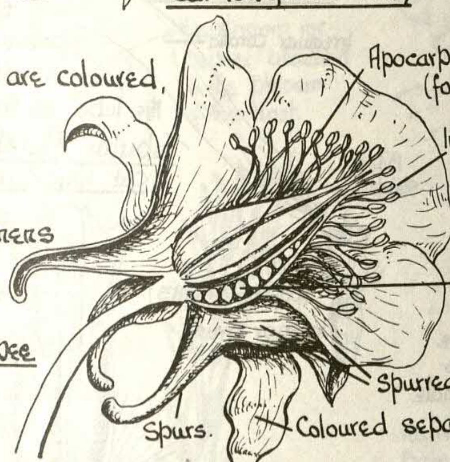
When the bee alights to get nectar, the stamens brush its under surface. In the later female stage the stamens coil back and the stigmas are exposed.

It is from this plant that the poisonous alkaloid - Aconitine is obtained

b) Columbine (Aquilegia)

Protandrous.





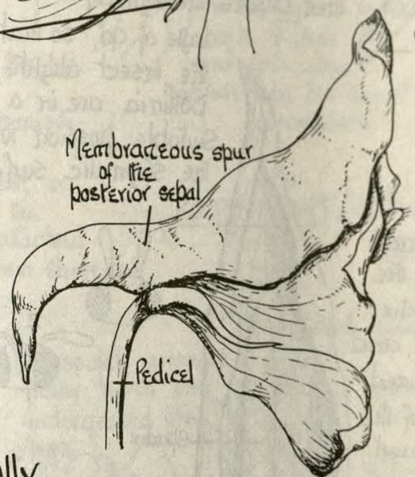
The five sepals are coloured, while the five spurred petals produce nectar. The central stamens are sterile, and form a column on to which the bee clings during pollination.

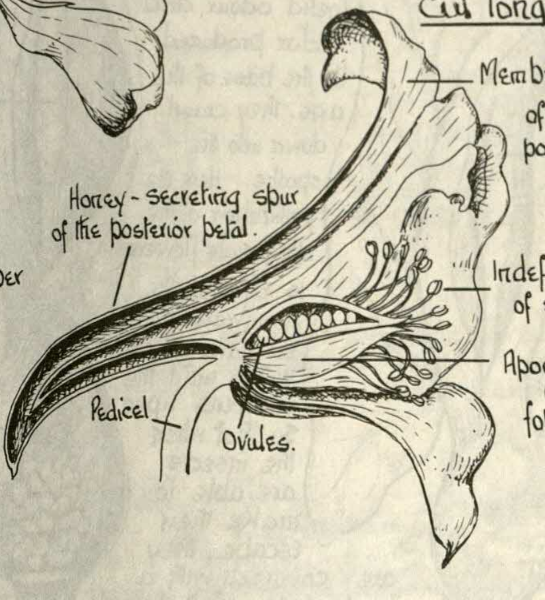
c) Larkspur (Delphinium)

Protandrous.

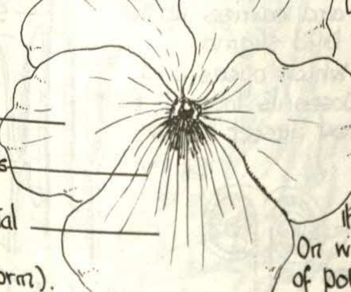
An irregular flower with five coloured sepals; the posterior sepal being spurred and containing the two nectar-secreting spurs of the two posterior petals.

The seeds are poisonous





VIOLACEÆ. - VIOLA tricolor.

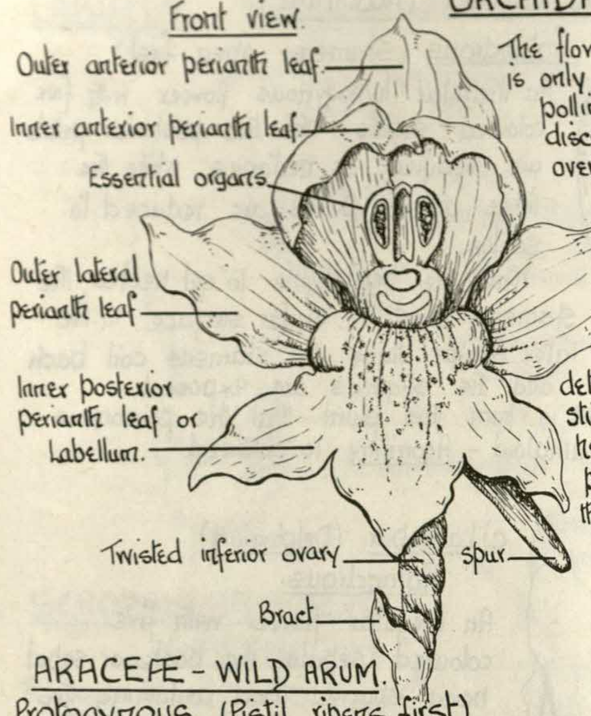


The anterior petal of this irregular (zygomorphic) flower is prolonged to form a spur, in which the nectar-secreting projections of the two anterior stamens lie. The stigma is provided with a lid hinged towards the base of the flower. As the insect probes for nectar, pollen is deposited into the pit from the insect's proboscis. On withdrawing, with a fresh supply of pollen, the lid is closed and self-pollination is prevented.

M.W.M.J.

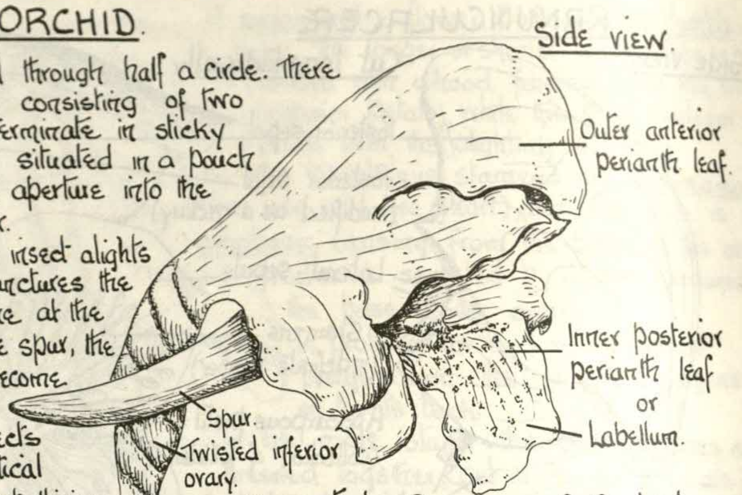
INSECT POLLINATION - SPECIAL ADAPTATIONS.

ORCHIDACEÆ - ORCHID.

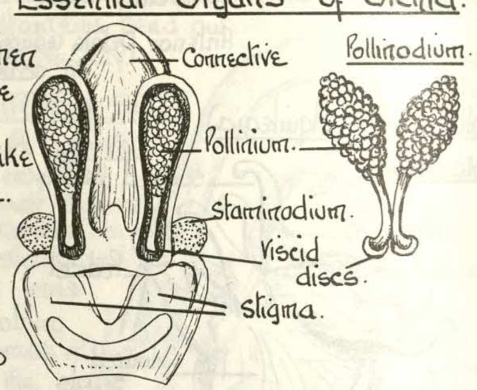


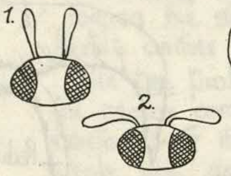
The flower is twisted through half a circle. There is only one stamen consisting of two pollinia which terminate in sticky discs and are situated in a pouch overhanging the aperture into the spur.

As the insect alights and punctures the membrane at the base of the spur, the two pollinia become detached and stick to the insects head in a vertical position. Each pollinium then passes through an angle of 90°, so that when the insect alights, the pollinia, are in a suitable position to strike the stigmatic surface.



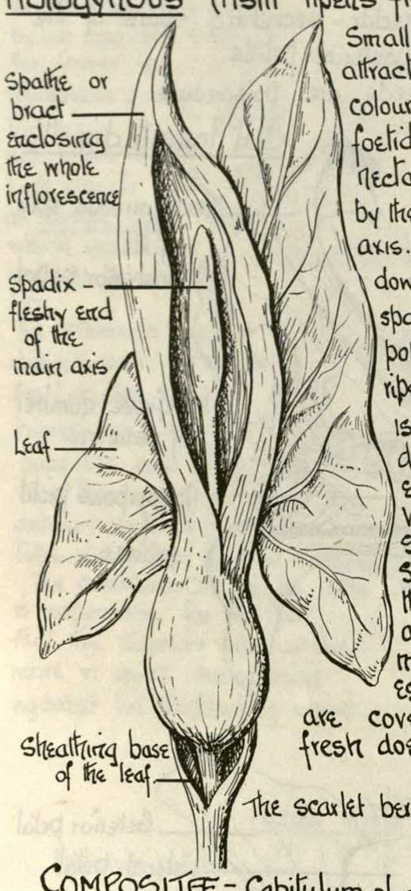
Essential Organs of Orchid.



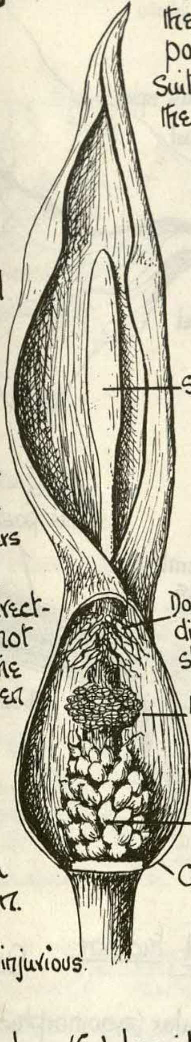


ARACEÆ - WILD ARUM.

Protogynous (Pistil ripens first.)

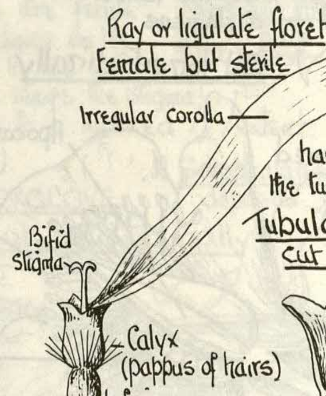


Small flies are attracted by the coloured spadix, foetid odour, and nectar produced by the base of the axis. They crawl down into the spathe. Here the pollination of the ripe female flowers is effected. The downwardly directed hairs do not wither until the stamens ripen so that when the insects are able to make their escape, they are covered with a fresh dose of pollen.



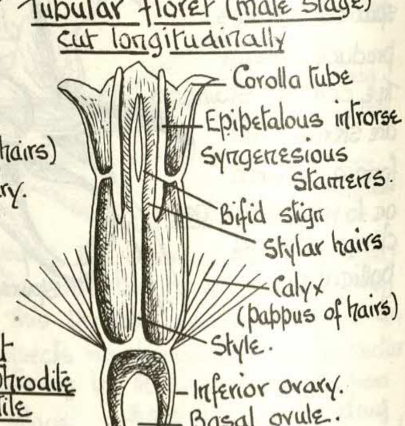
The scarlet berries are very injurious.

COMPOSITÆ

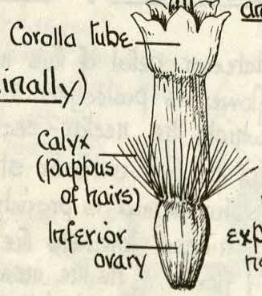


In the male stage, the introrse stamens shed their pollen on to the stylar hairs, which brush it up from the tube as the style elongates.

Tubular floret (male stage) Cut longitudinally

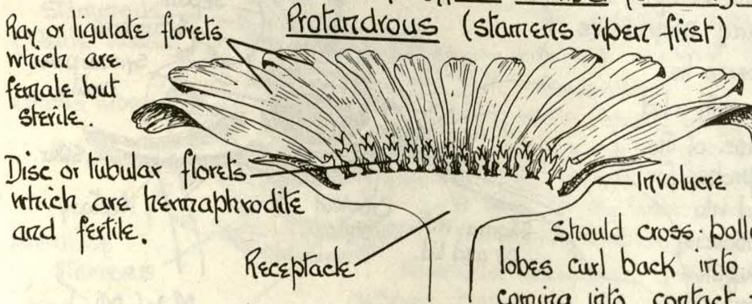


Disc or tubular floret Hermaphrodite and fertile



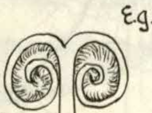
COMPOSITÆ - Capitulum of a typical member - (Cut longitudinally)

Protandrous (stamens ripen first)



In the Female stage the style elongates and carries up the bifid stigma, which opens and exposes it's lobes to the next insect visitor. Eg. Fly.

Should cross pollination fail, the stigma lobes curl back into the stylar hairs, thus coming into contact with the pollen of the same flower, so that self-pollination takes place.



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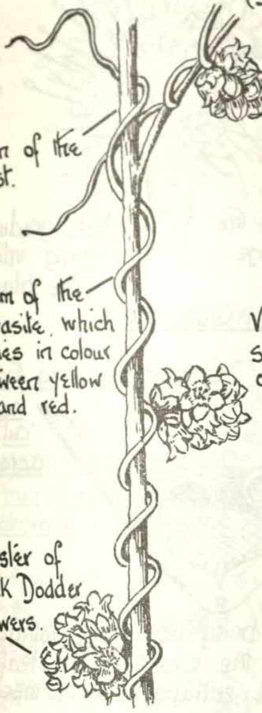
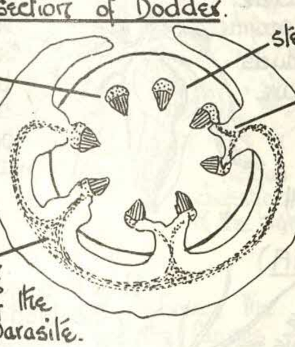
DODDER (Cuscuta) Parasite.

Dodder is characteristic in that:-
(1) It is a climber
(2) It attaches itself to the stem of the host.
(3) It possesses no roots in the mature condition



Diagrammatic longitudinal section of Host, and transverse section of Dodder plant.

Diagrammatic transverse section of Host and longitudinal section of Dodder.

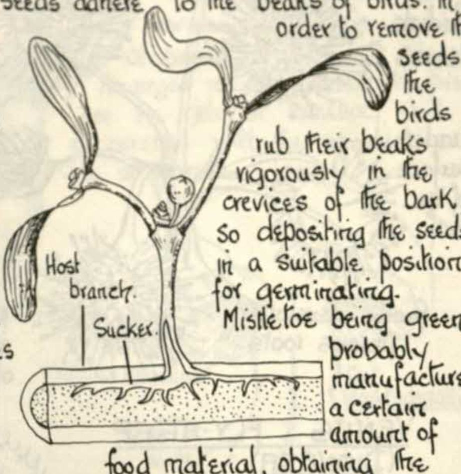


ORCHID - Epiphyte.

Many tropical orchids are unable to grow on the ground, owing to lack of light. The seeds therefore, germinate in the soil which accumulates in the crevices in the bark of trees. The aerial roots absorb moisture from the humid atmosphere.

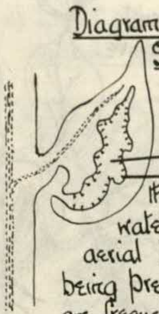
MISTLETOE (Viscum) Semi-parasite

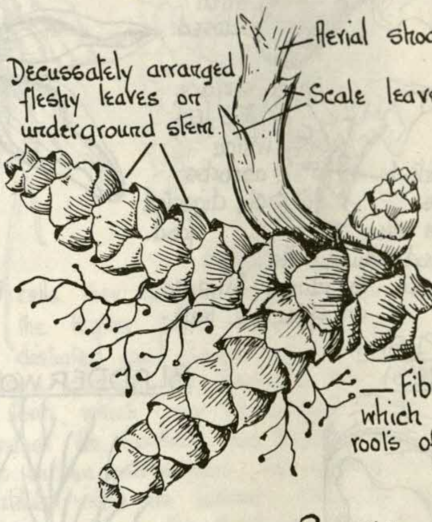
Unlike parasites, it develops chlorophyll. The chief hosts are Apple and Hawthorn. The berries are very sticky and the seeds adhere to the beaks of birds. In order to remove the seeds the birds rub their beaks vigorously in the crevices of the bark, so depositing the seeds in a suitable position for germinating. Mistletoe being green probably manufactures a certain amount of food material, obtaining the necessary salts from the host.



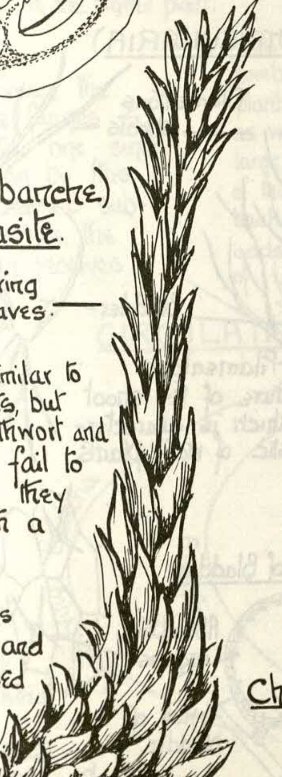
TOOTHWORT (Lathræa.) Parasite

Diagrammatic longitudinal Section of Toothwort





BROOMRAPE (Orobanche) Parasite.



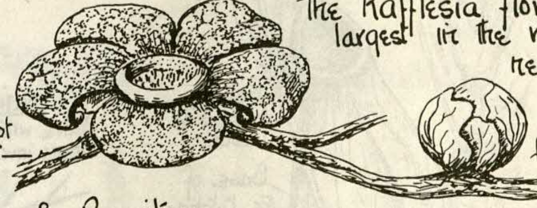
Broomrape is very similar to Toothwort in its habits, but unlike those of Toothwort and Dodder, its seeds fail to germinate unless they are in contact with a suitable host.

In Dodder the seeds germinate normally and the seedlings provided with roots, flourish if they come into contact with a suitable host.

RAFFLESIA. Parasite

This plant is a native of Malaya and is parasitic on Vines. The parasitic habit is so established that the whole vegetative part is reduced to the minimum, and is represented by the sucker or haustorium. Large buds appear on the roots of the host, which when they open form large, bright red flowers.

The Rafflesia flower is probably the largest in the world, measuring nearly one yard in diameter, and weighing about fifteen pounds. It emits an offensive odour.



Characteristics of Parasites

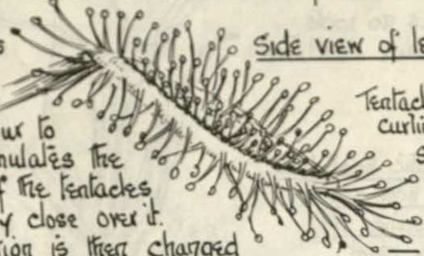
1. No chlorophyll is developed.
2. Organic connection between parasite and host.
3. Reduction of vegetative parts, according to the degree of parasitism.
4. Prolific reproduction.

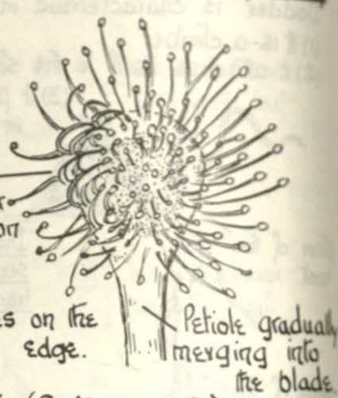
M. W. M. J.

ABNORMAL MODES OF NUTRITION - CARNIVOROUS PLANTS.

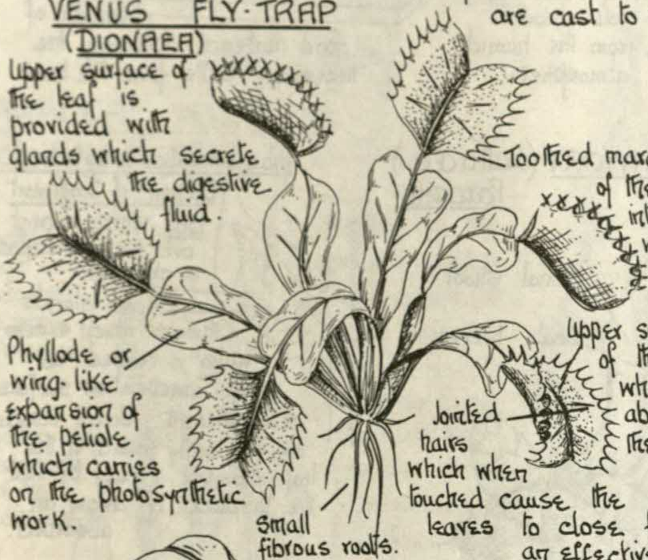
SUNDEW (DROSERA)

The club-shaped tentacles secrete a glistening fluid which is attractive to flies. When a fly alights it sticks to the secretion of the tentacles. In its endeavour to escape it stimulates the movement of the tentacles which finally close over it. The secretion is then changed to that of a digestive ferment, which acts upon the soft parts of the insect. After the process of absorption the leaves open and the remains are cast to the wind.



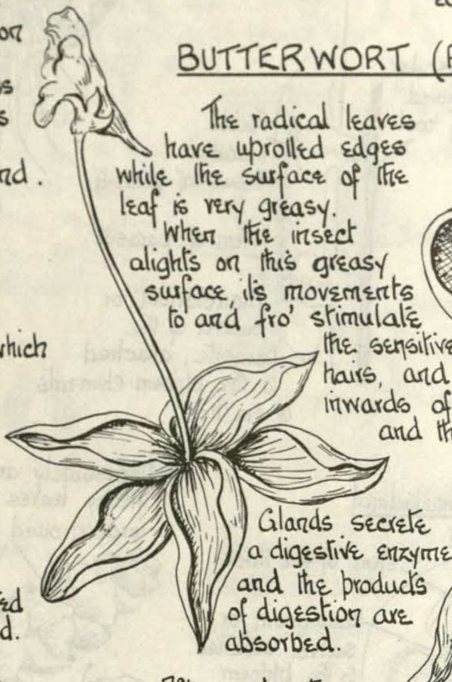


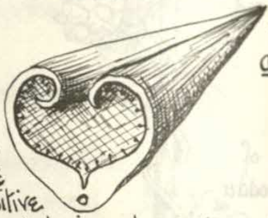
VENUS FLY-TRAP (DIONAEA)

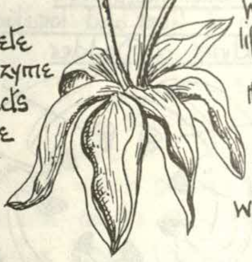


BUTTERWORT (PINQUICULA)

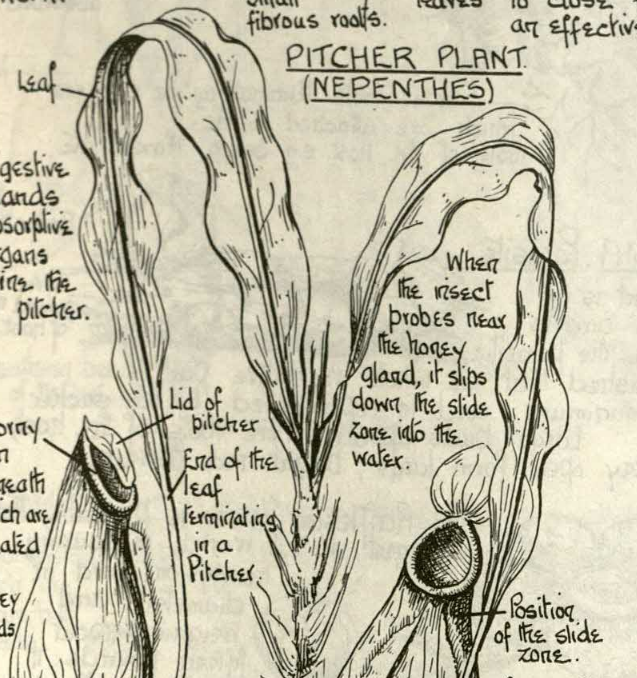
The radical leaves have uprolled edges while the surface of the leaf is very greasy. When the insect alights on this greasy surface, its movements to and fro' stimulate the sensitive hairs, and bring about the rolling inwards of the edges of the leaf and the entrapping of the insect.



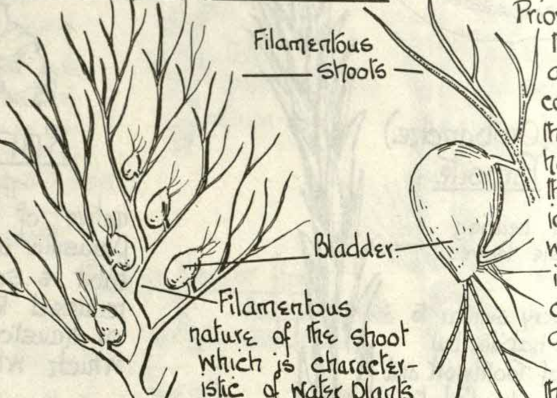




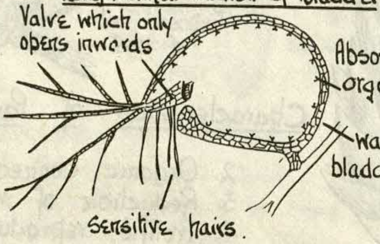
PITCHER PLANT (NEPENTHES)

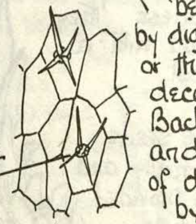


BLADDERWORT (UTRICULARIA)



Prior to stimulation the bladder is in a collapsed condition. When the sensitive hairs are touched the valve opens inwards, rapidly, with a resulting inrush of water containing small animal life. The bodies of the latter may be acted upon by digestive juices, or they may be decomposed by Bacterial action and the products of decay absorbed by the absorptive organs, in which case the plant might be regarded as a partial saprophyte.





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YELLOW BIRD'S NEST (MONOTROPA)

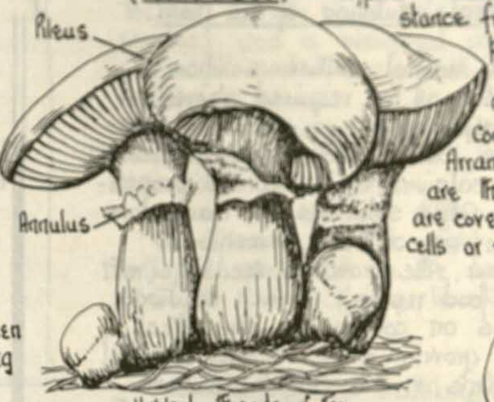
This plant which inhabits beech-woods is quite devoid of chlorophyll. It is entirely dependent, therefore, upon the organic substance present in the soil, which it receives by means of a saprophytic fungus.

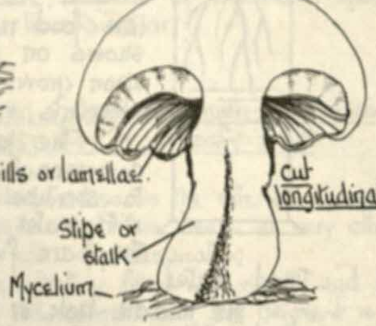
The latter makes its way into the cells of the underground parts of the higher plant. The free ends of the fungus ramify between the soil particles, absorbing the organic material and passing it on to the plant.

This association of higher plant and fungus is known as a Mycorrhiza.

MUSHROOM (AGARICUS)

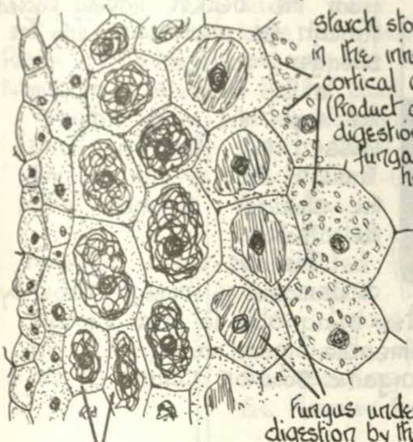
The underground mycelium consisting of hyphal threads absorbs the organic substance from the soil, on which the plant is entirely dependent. The fructification is the overground structure, and is comprised of stipe and pileus. Arranged radially beneath the pileus are the gills or lamellae, which are covered with the reproductive cells or spores.





a) BIRD'S NEST ORCHID (NEOTTIA)

Transverse section of Root showing endotrophic Mycorrhiza.

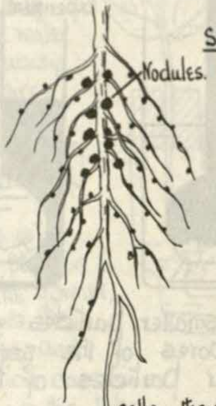


The association between the higher plant and the fungus is probably a symbiotic one, since the higher plant can by this means utilise the organic substance of the soil, while the lower plant in return receives shelter.

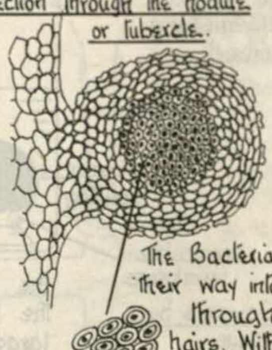
SYMBIOSIS

b) Leguminous Root Nodules.

Bacillus radicicola.



Section through the nodule or tubercle.

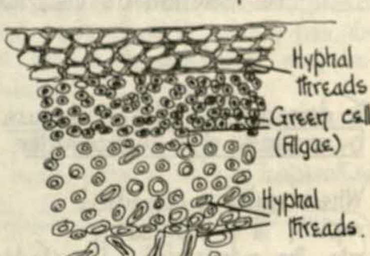


The Bacteria make their way into the roots through the root hairs. Within the root cells they increase rapidly, the tissue of the higher plant becoming swollen and distorted and so forming the nodule.

The Bacteria change the gaseous nitrogen into a combined form, which can be utilised by the green plant. In return the Bacteria are provided with shelter as well as carbonaceous food, the latter occurring in large quantities within the tubercle cells. On the death of the Leguminous plant, the Bacteria make their way back into the soil, while the ensuing decay of the plant adds to the nitrate content of the soil. Hence the importance of Leguminous plants in the rotation of crops.

c) LICHENS e.g. Peltigera.

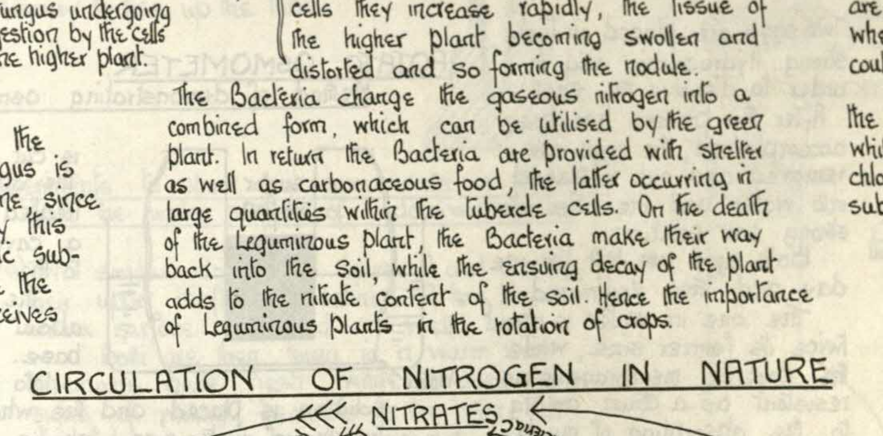
Vertical section of Thallus.



By this association the Lichens are able to live in situations where neither Fungus nor Alga could thrive alone.

The Fungus protects the Alga and obtains moisture, while the Alga by virtue of its chlorophyll can build up organic substance, the latter contributing to the food of the Fungus.

CIRCULATION OF NITROGEN IN NATURE



Denitrifying Bacteria

(i) require oxygen, but not necessarily atmospheric. They get their supply by breaking down nitrates.

(ii) remain active in the presence of organic material.

Nitrifying Bacteria

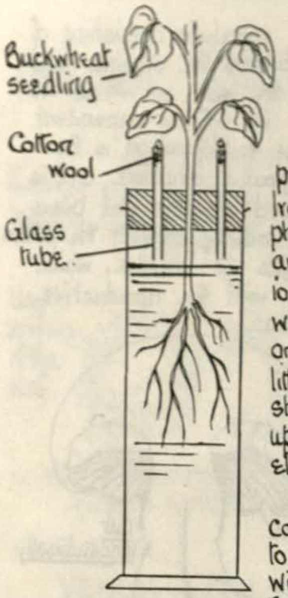
(i) must have atmospheric oxygen.

(ii) cease to be active in the presence of organic material.

(iii) Partly responsible for replenishing nitrate matter.

M. W. M. J.

10. THE PLANT IN RELATION TO ITS WATER SUPPLY - OSMOSIS - ROOT PRESSURE.



Experiments to show that certain elements are necessary for the normal nutrition of the plant.

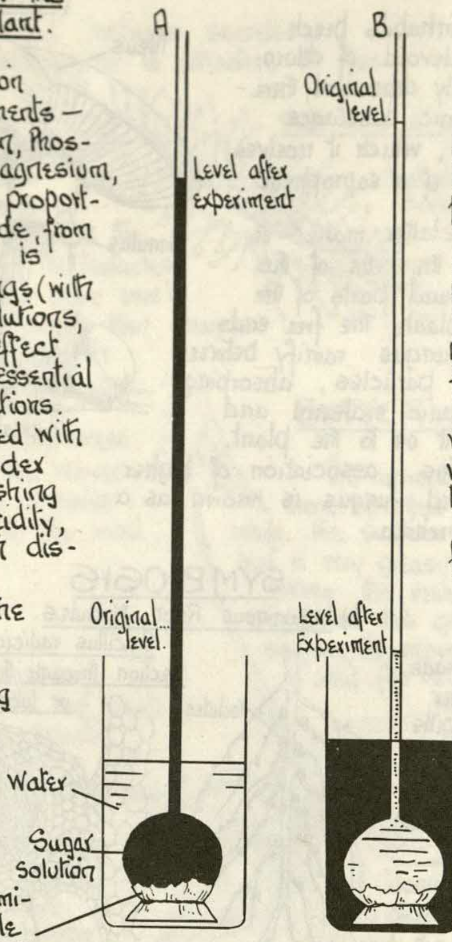
The normal culture solution provides all the required elements — Iron, Hydrogen, Oxygen, Nitrogen, Phosphorus, Sulphur, Potassium, Magnesium, and calcium in the correct proportions. Other solutions are made, from which one of these elements is omitted. The growth of seedlings (with little food reserve) in such solutions, shows on comparison the effect upon growth of the various essential elements in the culture solutions.

The jars are first rinsed with commercial Nitric acid in order to sterilise them. After washing with water to remove the acidity, they are finally rinsed with distilled water.

The middle hole in the cork holds the plant, while the two side holes contain glass tubing plugged with cotton wool.

These tubes are used for replenishing the solution as the latter is absorbed.

Experiment to demonstrate Osmosis (one-sided diffusion)



The mouths of two thistle funnels are covered with pieces of pig's bladder as shown in the diagram.

This membrane is semi-permeable, i.e. with pores large enough to allow the smaller particles of water to pass through, but not large enough to allow the bigger particles of the organic (sugar) solution to pass through.

In A the solution is within the bulb of the funnel, while water fills the beaker.

In B the condition is reversed, water filling the bulb of the funnel, while the sugar solution is in the beaker.

The level of the liquid in the funnel is marked in both cases.

In A there is a rise of the liquid in the stem, the water from the beaker having passed through the membrane into the stronger solution.

In B there is a drop in the level, the water having passed out from the funnel through the membrane into the stronger solution within the beaker.

This one-sided diffusion or Osmosis is brought about by the smaller particles of water being able to pass through the pores of the semi-permeable membrane, while the larger particles of the organic solution cannot do so.

To demonstrate Root pressure by means of a Manometer.

When water is absorbed rapidly it is pumped into the xylem with great vigour, resulting in a forcible upward pressure.

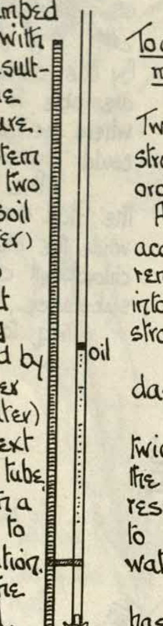
A marrow stem is cut off about two inches above soil level (under water)

To this stump about three feet of glass tubing is firmly fixed by means of rubber tubing (under water)

Water is next poured into the tube, and covered with a thin layer of oil to prevent evaporation.

The level in the tube is marked, the soil is watered, and the whole put into a warm place.

The water in the tube is soon observed to be rising.



To demonstrate Osmosis by means of two eggs.

Two eggs are placed in fairly strong Hydrochloric acid in order to dissolve the shell.

After this process has been accomplished, the eggs are removed and one is placed into water and the other into strong salt solution.

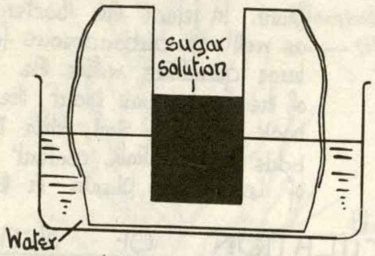
Both eggs are left for one day and then examined.

The one in water is about twice its former size, while the covering membrane is as resistant as a drum owing to the absorption of much water.

The one in salt solution has diminished considerably in size and is flabby to the touch, a condition which results from water loss.

POTATO OSMOMETER.

Method of demonstrating osmosis.



A washed potato is cut across to form a base. The opposite end is similarly treated, but in addition has a cavity cut into it almost to the base.

The peel is removed from about one inch above the base.

Into the cavity strong sugar solution is placed, and the whole then put into a trough of water as shown in the diagram.

After a time the liquid in the cavity is seen to have risen osmosis having taken place.

When a boiled potato is treated similarly, osmosis does not take place.

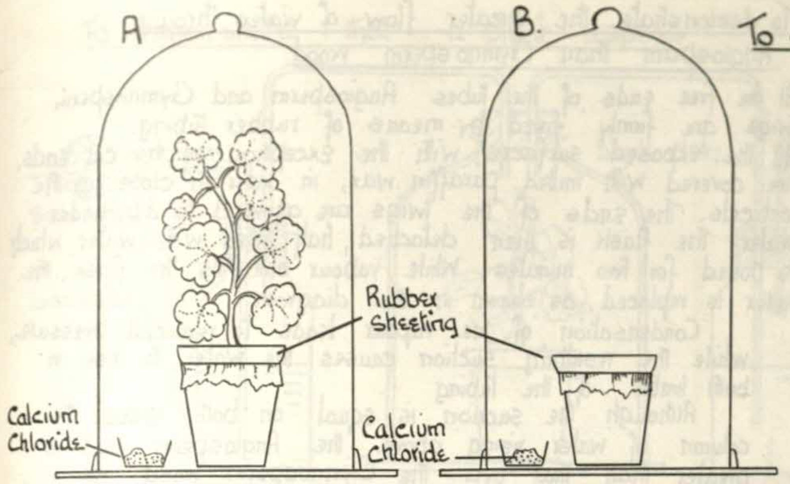
ABSORPTION OF WATER AND MINERAL SALTS BY THE PLANT.

Although the cellulose wall of the root hair is permeable, the cytoplasmic lining is semi-permeable - so that wall plus cytoplasm constitutes a semi-permeable membrane. While this allows the passage of water in both directions, the net flow is from the zone of greater water concentration (in the soil) to that of less water concentration (in the cell).

The resulting one-sided diffusion is known as OSMOSIS.

The mineral salts from the soil gain entrance in the form of electrically-charged particles or IONS which not only pass through the cellulose wall but also through the interstices of the cytoplasm.

THE PLANT IN RELATION TO ITS WATER SUPPLY - TRANSPIRATION.



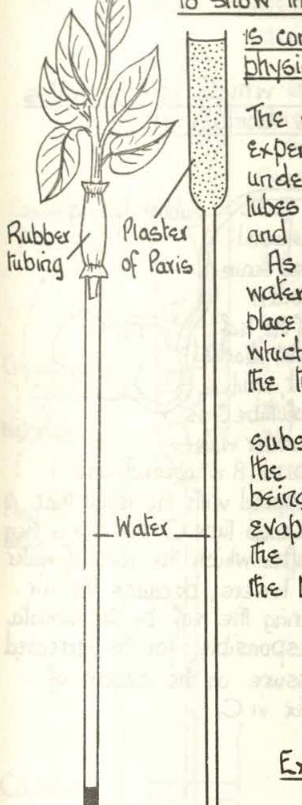
To show that a potted plant transpires.

The soil in both plant pots is covered with rubber sheeting, and a weighed amount of Calcium Chloride is placed under each bell jar, and the whole left for twenty-four hours.

The increase in the weight of the Calcium Chloride of the control B is due to a change in the atmospheric conditions

If this difference is subtracted from the difference in the weight of the calcium chloride in A, the result will be the amount of moisture given off by the plant during transpiration.

To show that Transpiration is comparable with a physical phenomenon.

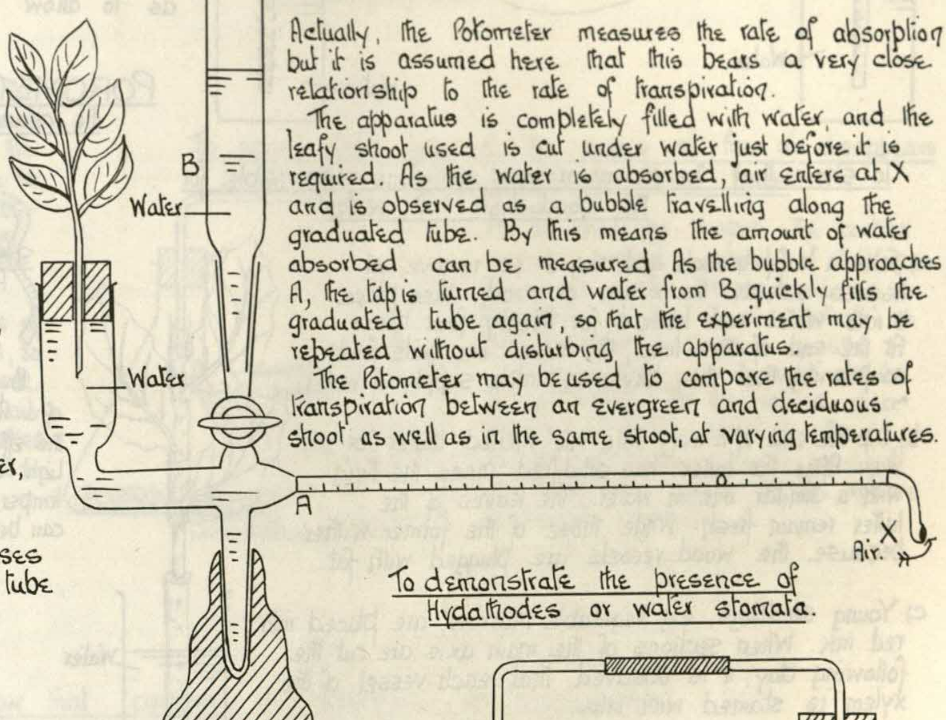


The shoot used for this experiment must be cut under water. Both long tubes are filled with water and inverted into Mercury.

As the plant transpires water is absorbed, and its place is taken by the Mercury, which as a result rises up the tube.

Plaster of Paris is substituted for the plant in the second tube. The former, being porous, allows the evaporation of water, and the resulting suction causes the Mercury to rise up the tube.

A POTOMETER is an instrument which measures the rate of transpiration in a leafy shoot.

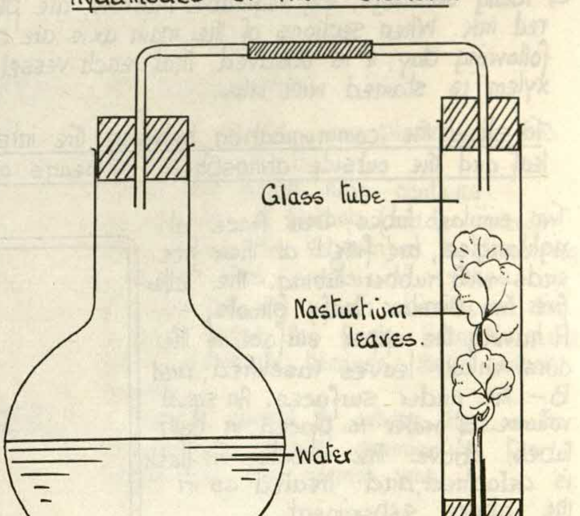


Actually, the Potometer measures the rate of absorption but it is assumed here that this bears a very close relationship to the rate of transpiration.

The apparatus is completely filled with water, and the leafy shoot used is cut under water just before it is required. As the water is absorbed, air enters at X and is observed as a bubble travelling along the graduated tube. By this means the amount of water absorbed can be measured As the bubble approaches A, the tap is turned and water from B quickly fills the graduated tube again, so that the experiment may be repeated without disturbing the apparatus.

The Potometer may be used to compare the rates of transpiration between an evergreen and deciduous shoot as well as in the same shoot, at varying temperatures.

To demonstrate the presence of Hydathodes or water stomata.



The flask is half filled with water, and when detached is boiled. While vapour still fills the flask, the latter is replaced as in the figure.

Condensation of water results in reduced pressure, which culminates in a suction, drawing in first air and then water by way of the leaf. This water is seen to collect in drops at the ends of the main veins at the leaf margin.

Experiments to show that more water is given off from the under surface of a dorsiventral leaf.

a) Two similar dorsiventral leaves A and B, have their upper surfaces vaselined. A has the under surface vaselined as well.

Both are then hung in a warm room. A remains quite fresh while B soon shows signs of wilting, because in the latter the stomatal apertures are uncovered, and water is given off freely in the process of transpiration.

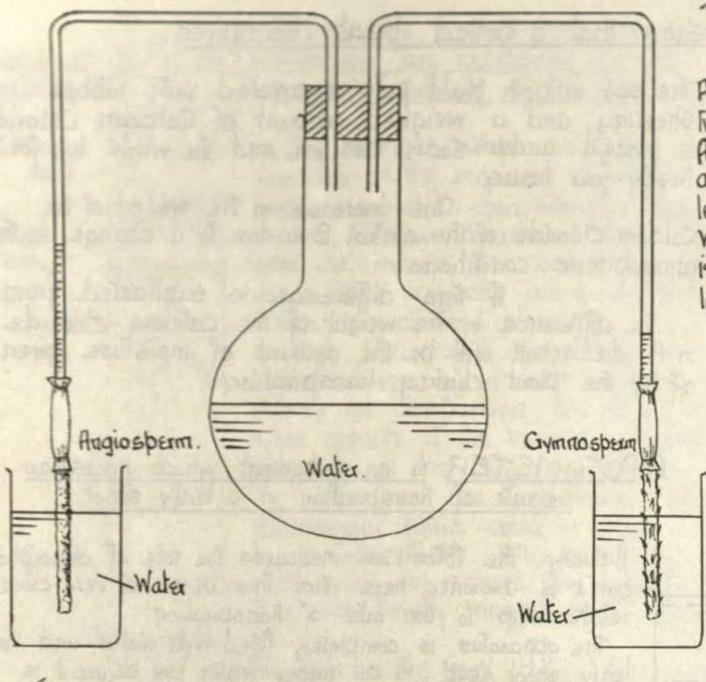
b) Pieces of filter paper are placed in Cobalt chloride solution and allowed to dry, when they assume a blue colour.

Dorsiventral leaves are detached from a well-watered plant, and placed flat onto a sheet of paper, one half with their upper surfaces uppermost, and the remaining half with their lower surfaces uppermost.

Over each leaf is placed a piece of Cobalt chloride paper, and over the whole a piece of glass to prevent access of damp air. The chloride papers over the lower surfaces soon turn pink, showing the presence of moisture.

M.W.M.J.

THE PLANT IN RELATION TO ITS SUPPLY OF WATER AND AIR.



To demonstrate the greater flow of water through Angiosperm than Gymnosperm wood.

At the free ends of the tubes Angiosperm and Gymnosperm twigs are firmly fixed by means of rubber tubing. All the exposed surfaces, with the exception of the cut ends, are covered with melted paraffin wax, in order to close up the lenticels. The ends of the twigs are allowed to dip under water. The flask is then detached, half filled with water, which is boiled for two minutes. While vapour still fills the flask, the latter is replaced, as shown in the diagram.

Condensation of the vapour leads to reduced pressure, while the resulting suction causes the water to rise in both limbs of the tubing.

Although the suction is equal on both sides, the column of water rising above the Angiosperm wood is greater than that over the Gymnosperm wood, so showing that the structure of the Angiosperm is such, as to allow more rapid flow.

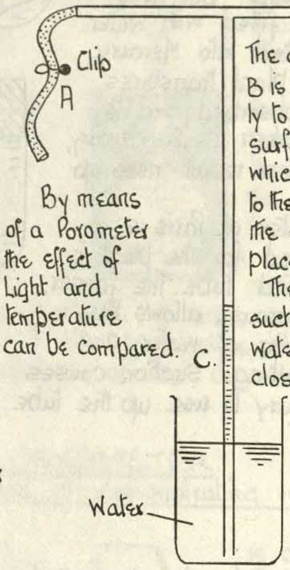
To show that the xylem or wood is alone responsible for the conduction of water.

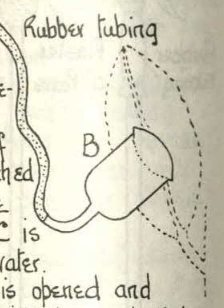
a) Take a leafy branch and ring it i.e. remove all tissues outside the xylem or wood. Then place it into water and leave it for twenty-four hours. At the end of this time, the leaves are quite fresh so proving that they have an ample supply of water.

b) Dip the end of a leafy twig into melted butter or wax. After the latter has solidified, place the twig with a similar one in water. The leaves of the latter remain fresh, while those of the former wither because the wood vessels are plugged with fat.

c). Young seedlings, e.g. Vegetable Marrow, are placed into red ink. When sections of the main axis are cut the following day, it is observed that each vessel of the xylem is stained with ink.

POROMETER. - An instrument which demonstrates the change in the width of the stomatal aperture.





The glass funnel B is applied securely to the under surface of the leaf which is still attached to the plant, while the end of tube C is placed under water.

The clip at A is opened and suction applied with the result that water rises up tube C. The clip is then closed, after which the level of water in C lowers, because the air entering the leaf by the stomata is responsible for the increased pressure on the column of water in C.

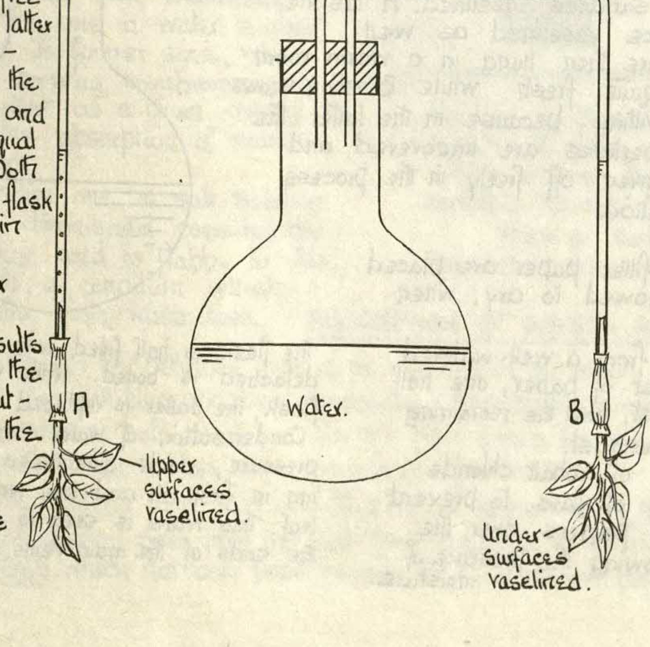
By means of a Porometer the effect of Light and temperature can be compared.

To show the communication between the interior of the leaf and the outside atmosphere by means of the Stomates.

Two similar tubes, bent twice at rightangles, are fitted at their free ends with rubber tubing. The latter fixes two similar leafy shoots - A having the upper surface of the dorsiventral leaves vaselined, and B - the under surfaces. An equal volume of water is placed in both tubes above the shoots. The flask is detached, and treated as in the above experiment.

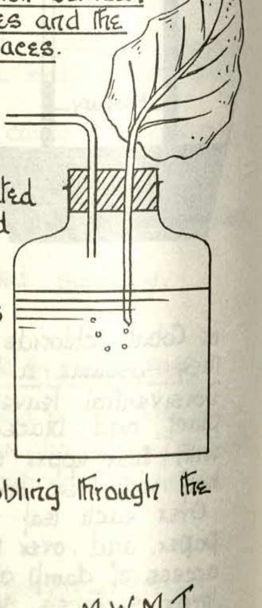
Condensation of the water vapour, is responsible for the reduced pressure, which results in a suction of air, through the water in tube A, from the outside atmosphere, by way of the stomatal apertures.

In B, no air bubbles appear as the stomatal apertures are in this case, blocked.



To show the close connection between the stomatal apertures and the intercellular spaces.

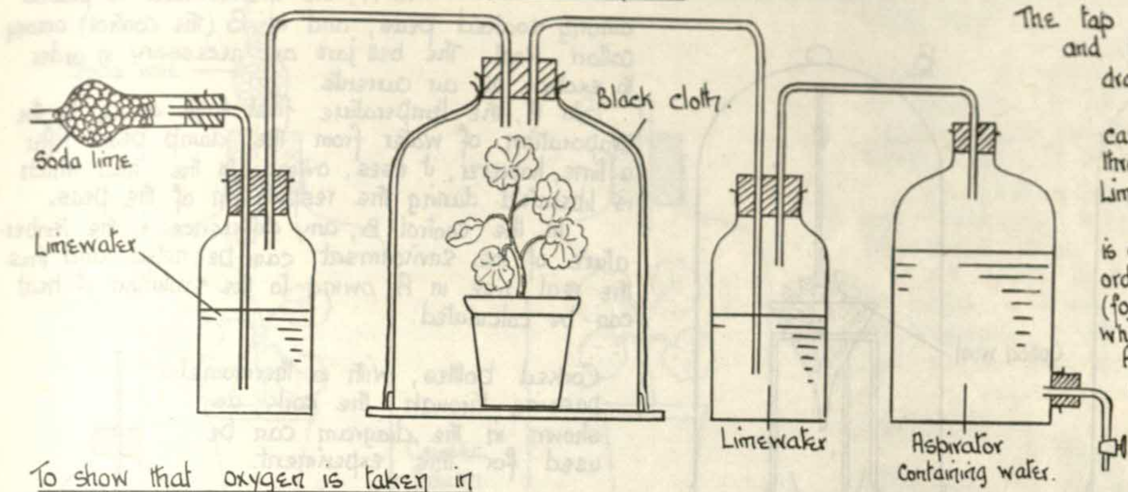
If suction is applied to the free end of the tube air is extracted from the jar, and this is replaced by the outside air which enters by the stomatal apertures, and after traversing the leaf blade and stalk, can be observed bubbling through the water.



M.W.M.J.

EXPERIMENTS TO DEMONSTRATE THE PROCESS OF RESPIRATION.

To demonstrate that a plant respires.



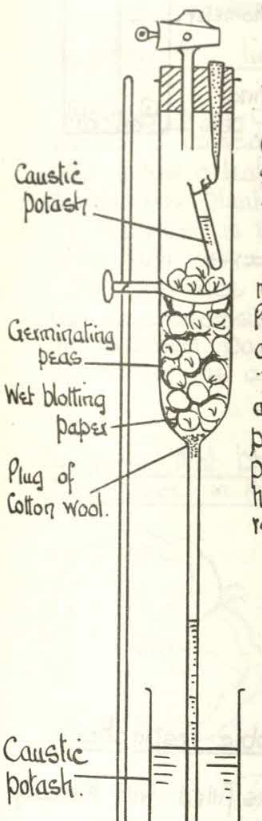
The tap of the Aspirator is turned on, and this is responsible for the drawing in of air.

The latter is deprived of carbon dioxide, by first passing through Soda lime and then Limewater.

The jar containing the plant is covered with a black cloth in order to prevent photosynthesis (food manufacture) taking place while respiration continues.

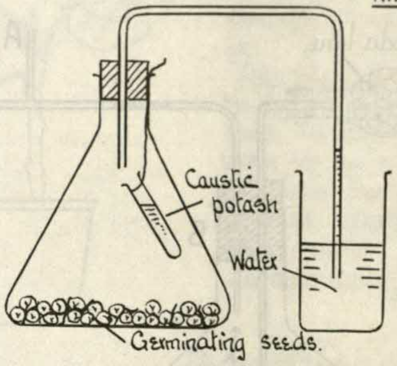
As a result of respiration carbon-dioxide is given off, and this is responsible for the milkiness of the second jar of Limewater

To show that oxygen is taken in during respiration.



The peas in the tube are respiring, giving out carbon dioxide. The latter is absorbed by the Caustic potash (KOH), with the result that there is reduced pressure which is responsible for the suction of KOH up the tube. When this has reached its maximum height, add crystals of Pyrogallic acid to the potash, so as to form pyrogallate of potash. This absorbs any oxygen available, but as no further rise takes place in the tube, no oxygen is present – thus proving that it has been used during the respiratory process.

To show that one of the gases of the air disappears when respiration takes place.

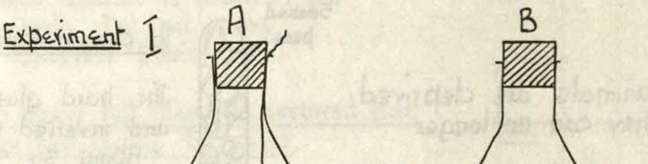


As the seedlings respire, the carbon dioxide evolved, instead of taking the place of the inspired oxygen, is absorbed by the Caustic potash, so that a reduced pressure results.

The suction so brought about is responsible for the intake of a volume of water equal to the volume of carbon dioxide evolved, and therefore equal to the volume of oxygen inspired.

To show that oxygen is essential for respiration.

Experiment I

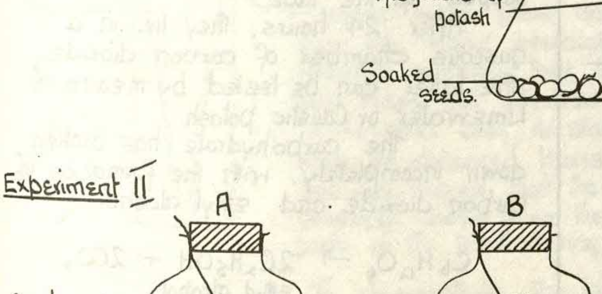


Soaked seeds are placed in two flasks, A and B.

In A, the small tube contains pyrogallate of potash (made immediately before the experiment by dissolving pyrogallic acid crystals in excess caustic potash) which absorbs all the oxygen within the flask. Here the seeds fail to germinate, because they cannot breathe.

In the control, B, where there is the necessary oxygen, germination proceeds in the normal way.

Experiment II



Here, small seeds such as Mustard are sprinkled on to moist sponges which are suspended in the bottles, A and B.

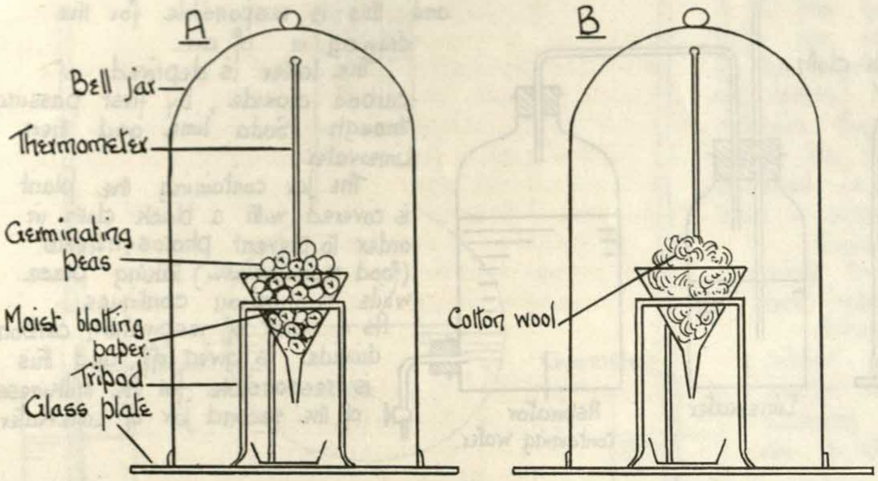
Bottle A, contains a little pyrogallate of potash, while B, contains only water.

In A, the seeds fail to germinate, while those in B make the usual progress.

M. W. M. J.

EXPERIMENTS TO DEMONSTRATE THE PROCESS OF RESPIRATION.

To show that heat is evolved during the process of Respiration.

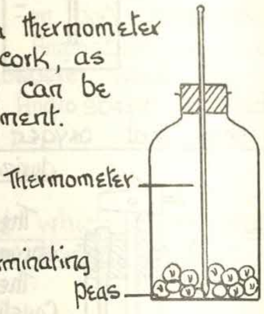


In A, the thermometer is placed among soaked peas, and in B (the control) among cotton wool. The bell jars are necessary in order to exclude all air currents.

In A, the temperature first falls owing to the evaporation of water from the damp peas. After a time, however, it rises, owing to the heat which is liberated during the respiration of the peas.

In the control B, any difference in the temperature of the environment can be noted, and thus the real rise in A, owing to the evolution of heat can be calculated.

Corked bottles, with a thermometer passing through the cork, as shown in the diagram can be used for this experiment.

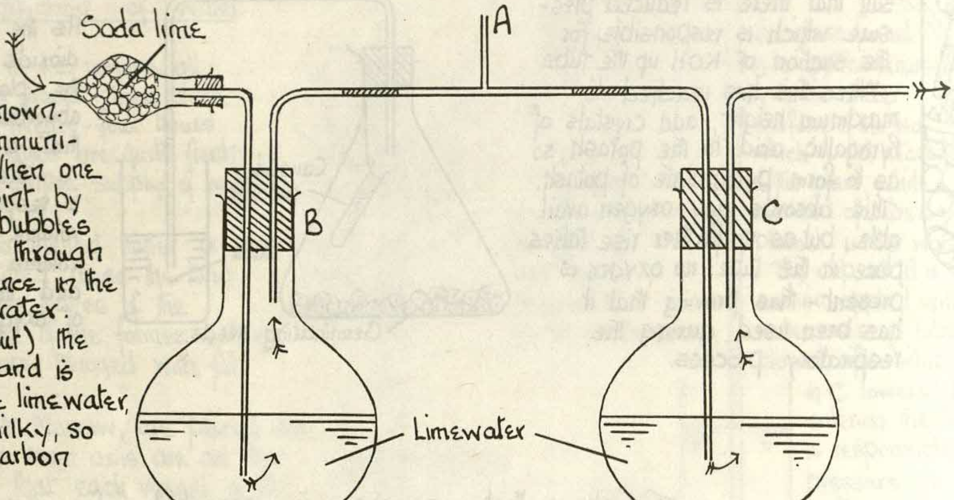


To demonstrate the presence of Carbon dioxide in exhaled air.

The apparatus is set up shown in the diagram. Limewater is placed in both flasks to the level shown.

The tube A communicates with both flasks. When one applies suction at this point by inhaling deeply, the air bubbles can be observed passing through flask B, causing little difference in the appearance of the limewater.

On exhalation, (breathing out) the air passes into flask C, and is seen bubbling through the limewater, which as a result goes milky, so proving the presence of carbon dioxide in exhaled air.



Anaerobic respiration.

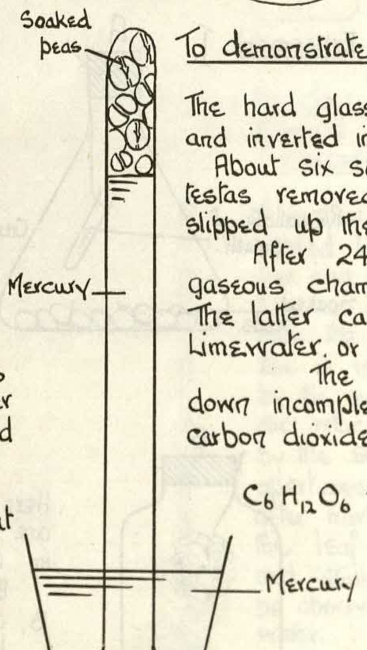
When animals are deprived of atmospheric oxygen, so that they can no longer breathe aerobically, they die.

Plants however, when deprived of this source of oxygen do not immediately succumb but undergo a modified process of breathing without oxygen, namely anaerobically.

In aerobic respiration, the oxygen taken in combines with the carbon of the carbohydrate, so that the products of the process are carbon dioxide and water vapour – in other words, there is an entire breakdown of the carbohydrate and complete liberation of energy.

In anaerobic respiration no oxygen is available, so that the carbohydrate breaks down incompletely with only partial liberation of energy.

The products of the process are carbon dioxide and ethyl alcohol. The latter, on accumulation is responsible for the death of the organism which produced it.



To demonstrate anaerobic respiration.

The hard glass tube is filled with Mercury. and inverted into Mercury.

About six soaked peas have their testas removed, after which they are slipped up the tube.

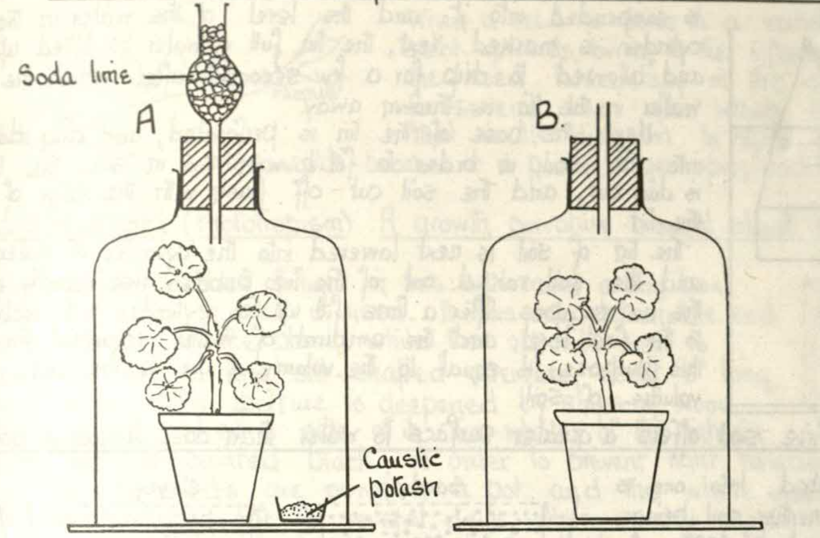
After 24 hours, they lie in a gaseous chamber of carbon dioxide. The latter can be tested by means of Limewater, or Caustic potash.

The carbohydrate has broken down incompletely, with the formation of carbon dioxide and ethyl alcohol.

$$C_6H_{12}O_6 \rightarrow \underbrace{2C_2H_5OH}_{\text{Ethyl alcohol}} + 2CO_2$$

M.W.M.J.

To show that atmospheric Carbon dioxide is necessary for photosynthesis (Food manufacture)



Experiment I.

In apparatus A, the incoming air is deprived of carbon dioxide by passing it through the soda lime in the tube. Within the bell jar is caustic potash which absorbs any carbon dioxide which might be there.

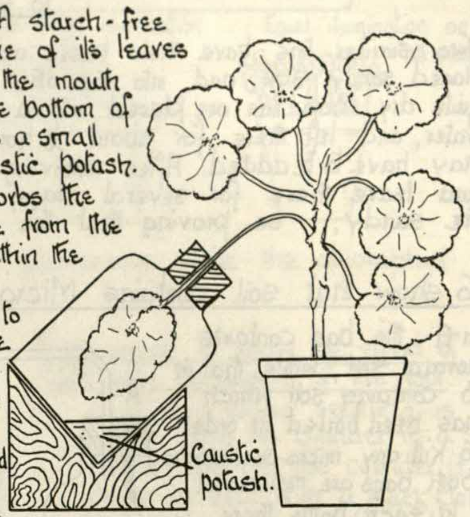
The plants used in A, and the control B, are both starch-free, and are exposed to the sunlight for several hours.

In the leaves of A, no starch is formed, while the leaves of B are starch laden, thus proving the necessity of the carbon dioxide, which is available in the normal air supply.

Experiment II

A starch-free plant has one of its leaves inserted into the mouth of a jar, in the bottom of which there is a small amount of caustic potash. The latter absorbs the carbon dioxide from the atmosphere within the jar.

After exposure to the light for some hours, the leaf within the jar is still starch-free while the exposed leaves contain abundant starch.

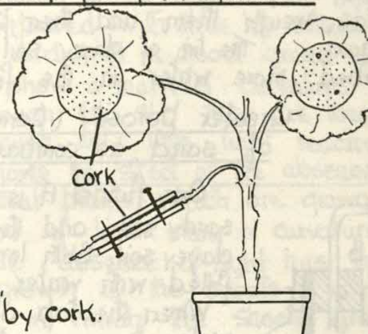


To show that light is necessary for photosynthesis.

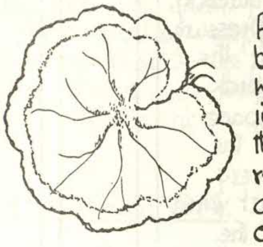
Two pieces of cork are placed to coincide above and below a leaf of a starch-free plant.

The whole is then placed in the light for a few hours.

The presence of starch can be demonstrated in all the exposed part of the leaf, but not in the area covered by cork.

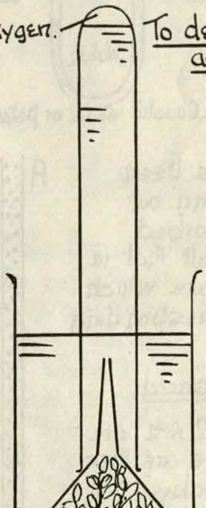


To prove that photosynthesis cannot take place in the absence of Chlorophyll.



A starch-free plant (one which has been kept in the dark for twelve hours) with variegated leaves is placed in bright light. After several hours the leaves are tested, with the result that starch is found in the green parts, but not in the cream-coloured parts.

To demonstrate the evolution of oxygen as a result of photosynthesis.



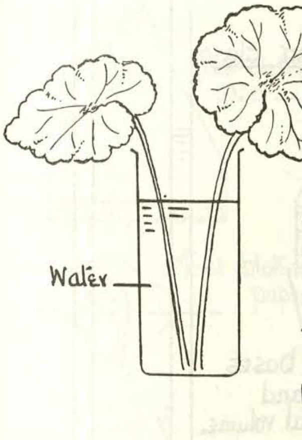
A green plant e.g. Elodea is placed beneath a funnel over the stem of which is inverted a test tube filled with water.

The water in the beaker is charged with carbon dioxide. The apparatus is then placed in the bright sunlight.

After some hours, a gas collects at the top of the tube, which can be tested and thus proved to be oxygen.

The carbon of the carbon dioxide has been retained by the plant for starch manufacture, while the oxygen has been liberated.

To show that starch is removed from the leaf during the night.



Detach two leaves from a starch-laden plant, and place them into water overnight. On the following morning, test these leaves and those still attached to the plant. In the latter case, no starch is present, while the detached leaves are starch-laden. This fact proves that the starch has been conveyed away from the leaves to other parts of the plant during the night.

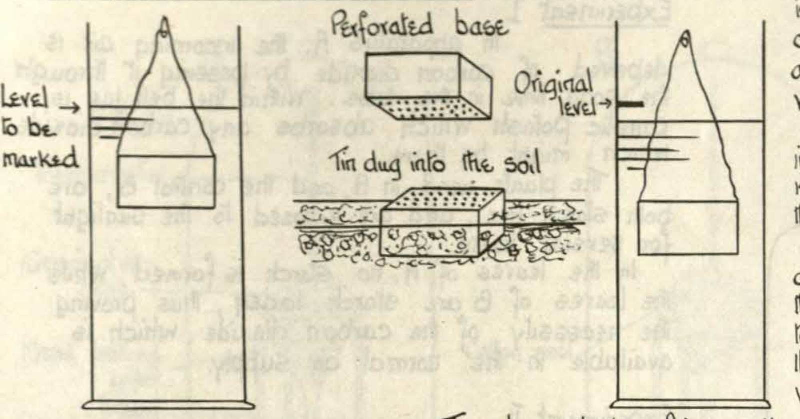
To demonstrate the presence of starch within the leaf.

Detach a leaf from a plant which has been exposed to the light for some time. Plunge it into boiling water, in order to kill it, and then place it into methylated spirit which gradually dissolves out the chlorophyll. In order to hasten the process, the whole may be heated in a porcelain basin over a water bath. When all the chlorophyll has been extracted, the leaf appears a dirty cream-colour, which on the application of iodine changes to blue-black — thus proving the presence of starch.

M.W.M.J.

16. EXPERIMENTS TO SHOW THE CHARACTERISTIC FEATURES OF THE SOIL.

To show that soil contains air.

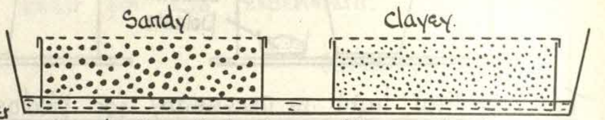


The glass cylinder contains water, and a tin full of water is suspended into it, and the level of the water in the cylinder is marked. Next, the tin full of water is lifted up, and allowed to drip for a few seconds, after which the water in the tin is thrown away.

Next, the base of the tin is perforated, and dug down into the soil, in order to fill it with soil in "situ". The tin is dug out, and the soil cut off flush with the edge of the tin.

The tin of soil is next lowered into the cylinder of water, and the soil raked out of the tin. Bubbles rise rapidly, and the air escapes. After a time, fill up the cylinder with water to the first level, and the amount of water required for this purpose, is equal to the volume of air in the tin's volume of soil.

To show that a fine soil offers a greater surface to water than does a coarse soil.

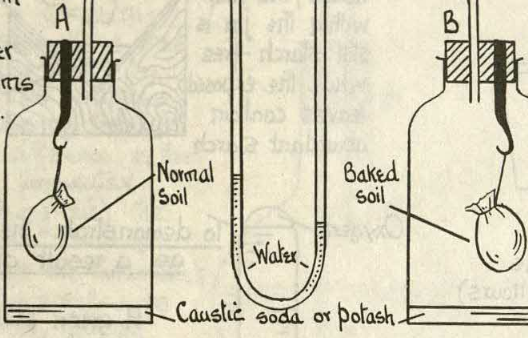


Two similar tins have their bases and lids perforated. Into one is placed sandy soil, and into the other clayey soil - neither soil being quite dry. Both tins are placed into a trough, with about ½" depth of water, and left there for about ½ hour, during which time, more water may have to be added. After removing and drying both tins, weigh them, and then put them into a drying oven, and leave there for several days, and then weigh again. The tin of clayey soil loses more weight than does the sandy, so proving that the clayey soil absorbed more water in the first instance.

To show that soil contains Micro-organisms

In A the bag contains normal soil, while that in B contains soil which has been boiled in order to kill any micro-organisms. Both bags are moistened.

In each bottle there is a little Caustic soda, while the U-tube contains coloured water. The whole apparatus is left for some time, with the result shown in the diagram.

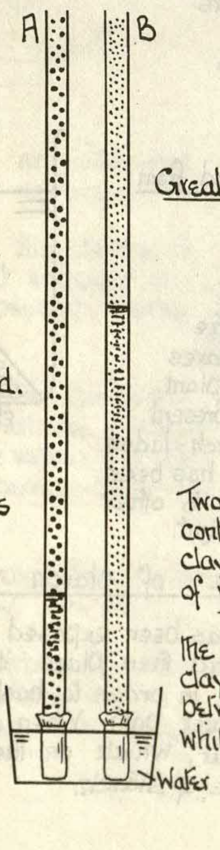


The microörganisms in soil A have been respiring, taking in oxygen and giving out Carbon dioxide, which has been absorbed by the caustic soda, with the result that in Bottle A, there is a reduced pressure which causes the liquid to rise in the corresponding limb of the tube.

Capillarity greater in clay than in sand.

Two glass tubes A and B, each about 2' x ½" are closed at one end by muslin. The tubes are then filled, A with sandy soil, and B with clayey soil. Both are placed into a trough of water as illustrated. After a time the water is seen to rise higher in B than in A, thus showing the capillarity of B to be greater than that of A.

This is because the capillary passages of B are narrower than those of A, and the particles of B, smaller than of A.



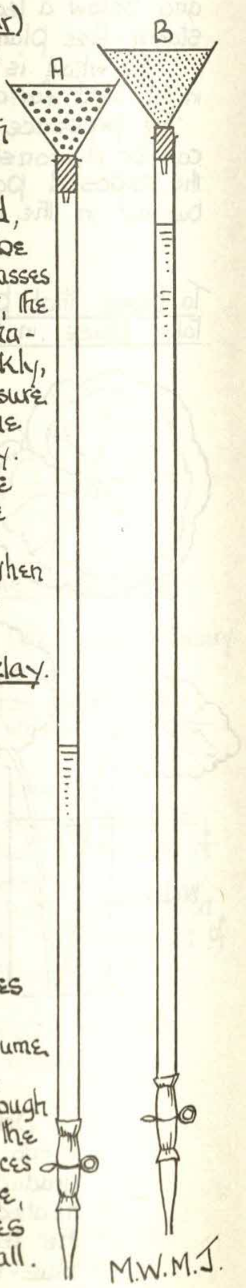
Sand	Clay.
Large particles.	Fine particles
Great air content.	Small air content.
Great permeability	Little permeability.
Little water content	Great water content.
Little capillarity	Great capillarity.

Greater porosity (permeability to air) of sand as compared with clay

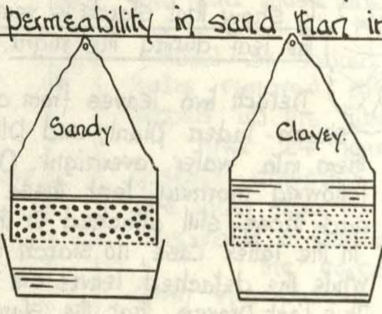
One funnel A is filled with sandy soil, and the other B, with clayey soil. Both long tubes are filled with water.

When the tap of A is opened, water passes out from the tube at the same rate as the air passes through the sand. In the latter, the pore spaces are large, thus enabling air to pass through quickly, which in its turn exerts a pressure upon the column of water in the tube, causing it to run out rapidly.

In clayey soil the pore space is small, with the result that the passage of air through is very slow, a fact which is evident when the tap of B is opened, and the water trickles out slowly.



Greater permeability in sand than in clay.



Two similar tins with perforated bases contain equal amounts of sandy and clayey soil. To each an equal volume of water is added simultaneously.

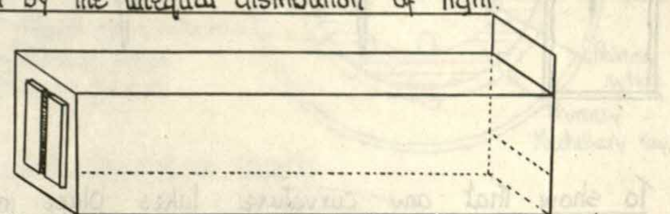
The water passes very quickly through the sandy soil, and slowly through the clayey. This is because the air spaces between the sand particles are large, while those between the clay particles are small.

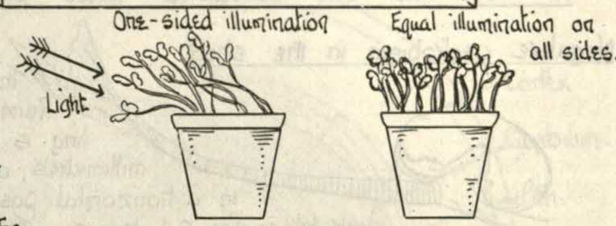
M.W.M.J.

GEOTROPISM. A growth curvature brought about by the unequal distribution of the stimulus afforded by gravity.

When a seed is sown in a vertical position, the root grows downwards, and the shoot upwards, owing to the influence of gravity. That this is so, is shown by placing the seed horizontally in the soil, and keeping the whole in a warm dark place for several days, after which the seedling presents an appearance similar to that in the diagram. In spite of the horizontal position, the radicle has grown downwards because it is positively geotropic, and the shoot upwards, because it is negatively geotropic.

HELIOTROPISM (Phototropism) A growth curvature brought about by the unequal distribution of light.





To show the influence of light in this experiment a long box about 2' x 1' x 1' in size is used. It has one detachable end for the insertion of the plant, while the opposite end is provided with a long slit-shaped aperture, about 6" long, by ¼" wide. This aperture is deepened by strips of wood being nailed on either side of it. The whole of the interior of the box is painted black, in order to prevent light reflection.

Mustard seeds are sown in a pot, and the whole inserted into the box and left for several days, while similar seeds are sown in a pot, which is kept in the light.

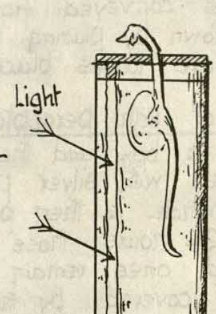
When the seedlings have grown to an appreciable size, those grown within the box are compared with those left outside. The latter are erect, short, but sturdy, and with a good green colour. Those from within the box, show a marked curvature towards the light, which reaches them through the slit. They are long and straggling in appearance, while the chlorophyll is very poorly developed, because only little light reaches them.

This experiment also shows the effect of the absence of light. Apart from the fact that plants which are grown exposed to unequal distribution of light show a curvature towards that source, complete absence of light has the effect of stimulating rapid growth of the shoots – a process known as etiolation, in which the shoots grow in order to get to the light.

Such shoots are long, thin and weakly, while the usual green is replaced by the characteristic yellow colour – chlorophyll having failed to develop because no light reaches the plant.

An everyday application of this fact is seen in the forcing of such plants as celery and rhubarb, where the edible leaf-stalks or petioles, grow enormously as a result of this treatment.

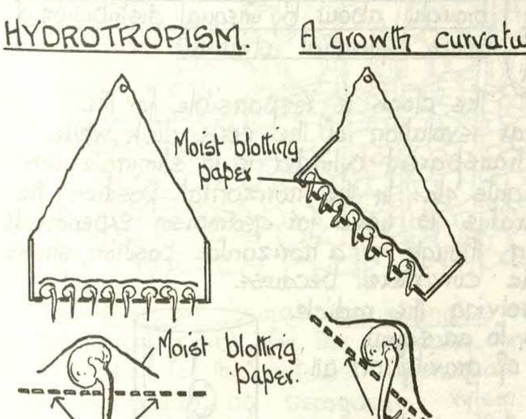
Experiment to show the effect of light upon the growth of the root.



A very young seedling is placed within the cylinder in a vertical position. The cylinder is almost covered with a black cloth so that the light is admitted along a narrow strip only.

The apparatus is placed in the light, and after some days the shoot shows the usual curvature towards the light, while the root bends in the opposite direction, being negatively heliotropic.

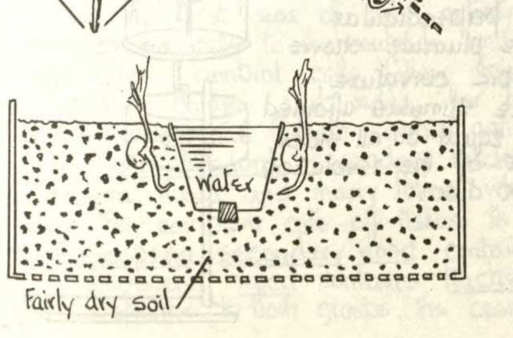
HYDROTROPISM. A growth curvature in roots resulting from the unequal distribution of moisture.



Soaked seeds are placed on a sieve and covered with moist blotting paper. It is then hung in a horizontal position in a warm place. When the radicles elongate, they grow straight down, so showing positive geotropism. That the radicles do not show a hydrotropic curvature is due to the fact that the source of moisture is equidistant from all sides of the radicle, so that the latter is in a state of equilibrium with regard to moisture.

A similarly equipped sieve is hung at an angle of 45°. When the radicles grow, they show a marked hydrotropic curvature, the radicles bending back into the sieve. Here, the distribution of moisture is unequal, so that the radicle bends until the tip receives the water stimulation equally on all sides, in spite of the influence of gravity.

To demonstrate positive Hydrotropism in roots



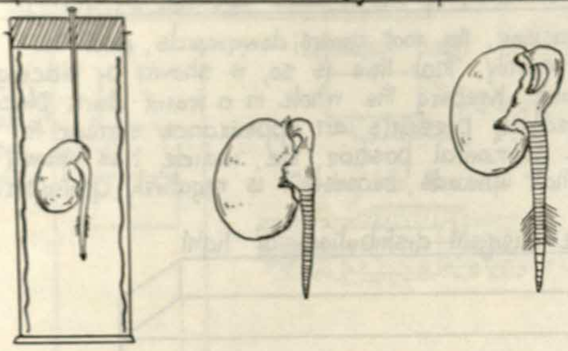
A wooden box with perforated base contains fairly dry soil. In the centre is placed an ordinary porous plant pot, in which the base is plugged, so that it may be filled with water, to the brim. Around the pot, soaked peas are set, their only source of moisture being that within the pot.

After about 10 days, the radicles, instead of growing down, are directed towards the pot, so showing that the root is positively hydrotropic.

M.W.M.J.

THE GROWTH OF THE ROOT AND SHOOT.

Experiment to show the region of maximum growth in a root.



Select a seedling with a straight radicle about one inch long, and by means of Indian ink mark off lines - one millemetre apart, from the tip backwards. Next fix the seedling in a jar lined with moist blotting paper, and place in the dark for about two days.

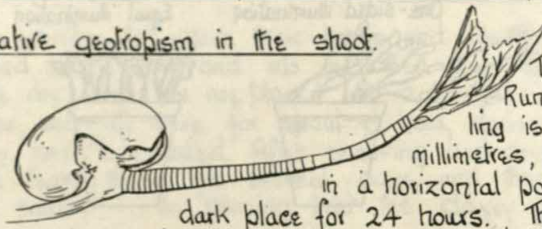
At the end of this time, the lines are no longer equally spaced - those between 4, 5, 6 and 7, have lengthened considerably, thus proving that elongation takes place some distance behind the tip.

As a result of this experiment, growth may be regarded as consisting of three phases from the tip backwards:-

(i) Formation of cells
(ii) Elongation of these cells.
(iii) Modification of the same cells

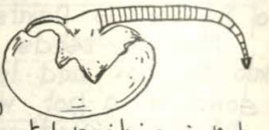
To show that any curvature takes place in the region of maximum growth.

Negative geotropism in the shoot.



The shoot of the Runner Bean seedling is marked off in millimetres, and placed in in a horizontal position, in a warm dark place for 24 hours. The negative geotropic curvature takes place in the region of maximum growth.

Positive geotropism in the root.



Here the root is marked off in millimetres from the tip backwards, and in a horizontal position is put into a warm dark place for 24 hours.

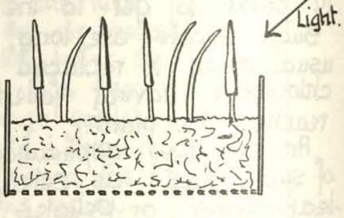
Here again the positive geotropic curvature takes place in the region of maximum growth.

Incidently these experiments also show that the region of elongation is longer in the shoot than in the root.

Although any growth curvature takes place in the region of maximum growth in both root and shoot, it appears that this is not the region where the stimulation is perceived, but that it is probably perceived by the tip or nearby, and by some means conveyed from there to the zone of growth curvature.

That this is the case is shown by placing seedlings in a horizontal position, and cutting off the extreme tip of the root. No geotropic curvature takes place.

Experiment to show that the power of light perception is localised.

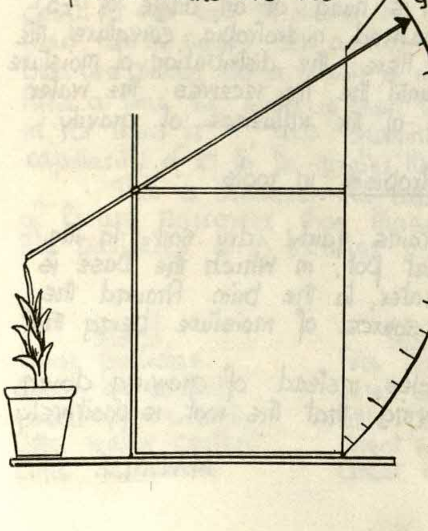


Monocotyledonous seeds are grown in a box, and the plumule sheaths of about half the number of seedlings, are covered with silver paper caps, which are first made and then gently pushed on. The whole is then placed in a dark box, illuminated from one end only. After about 24 hours those without caps show a definite heliotropic curvature. The covered ones remain perfectly straight, so that the perceptive power lies within the tip, covered by the paper.

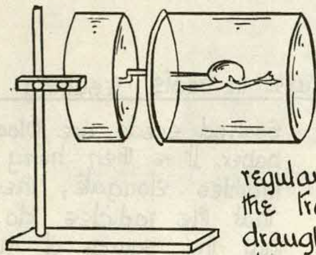
Growth Lever. - An instrument which magnifies the rate of growth, whereby it can easily be measured.

The pointer has a short arm attached to the plant, and a long arm terminating in a point which moves over a graduated arc.

The lever is light and riveted to a perpendicular bar, and it's unequal arms are made to balance by placing a weight on the short arm. As the shoot grows the pointer sinks over the graduated arc, and the amount indicated is to the actual growth as the length of the long arm is to the short arm of the lever

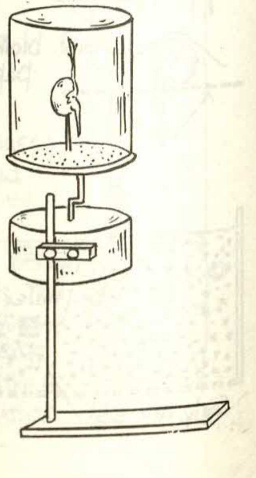


A Klinostat is an instrument which shows that any growth curvature is brought about by unequal distribution of some influential stimulus.



The clock is responsible for the regular revolution of the cork disk while the transparent cylinder is to eliminate any draughts etc. In the horizontal position the apparatus is used for geotropism experiments. The seedling, though in a horizontal position, shows no geotropic curvature because in the revolving the radicle is exposed to an equal distribution of gravity on all sides.

In a perpendicular position, the plumule shows no heliotropic curvature, because the stimulus afforded by light is equal on all sides, on account of the revolution of the cork disc.

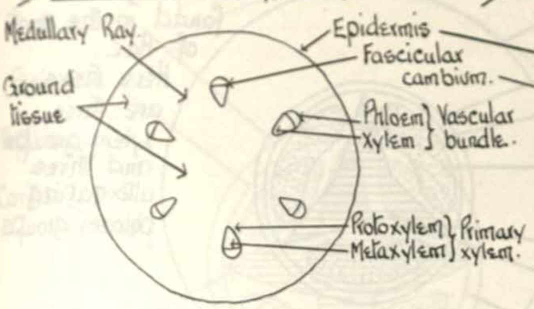


M.W.M.J.

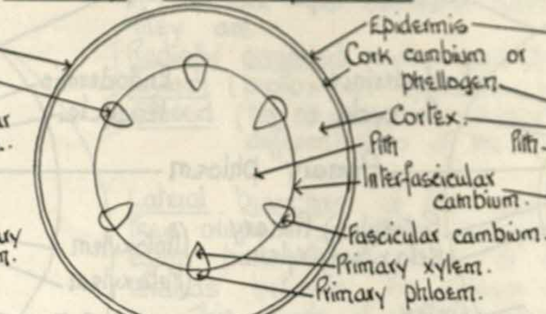
SECONDARY THICKENING IN DICOTYLEDONS - STEMS.

Diagrammatic transverse sections of a Dicotyledonous stem in various stages of secondary thickening.

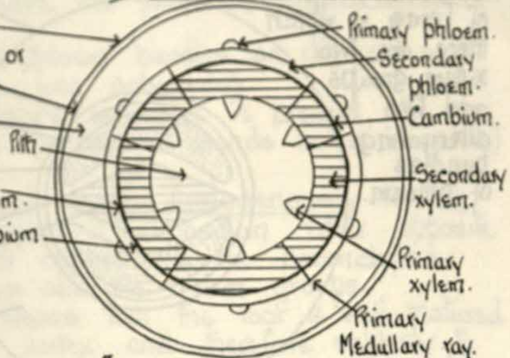
I. T.S. Plumule or Hypocotyl.



II Later stage - Formation of Cambium.

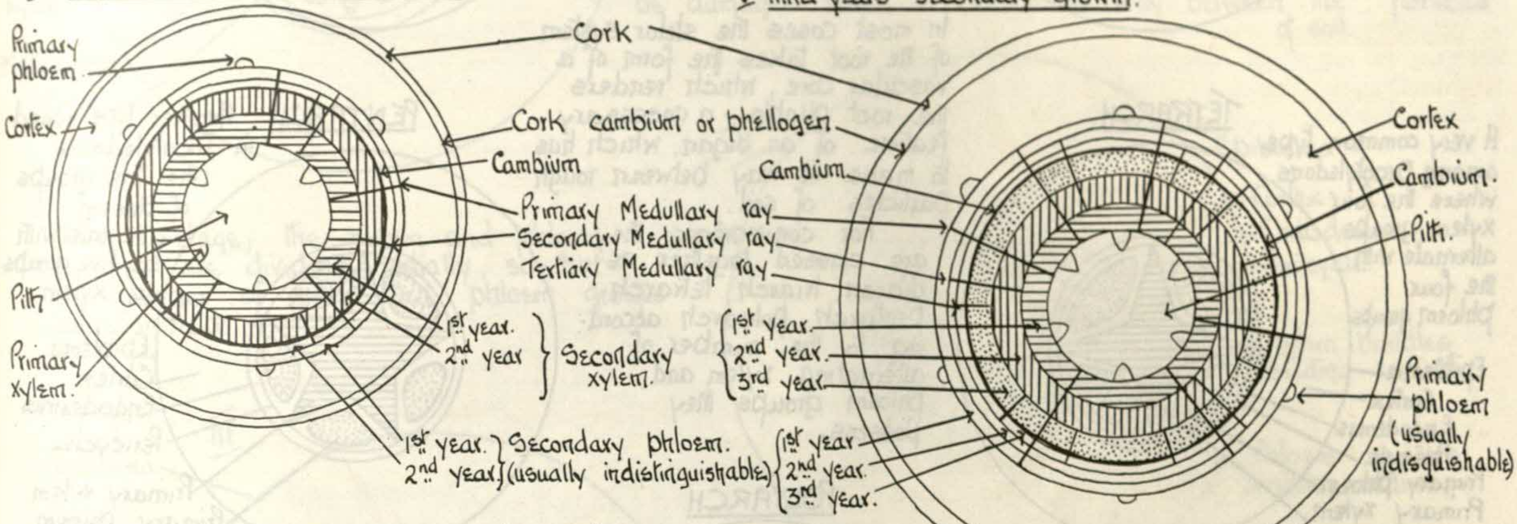


III First year's secondary growth.



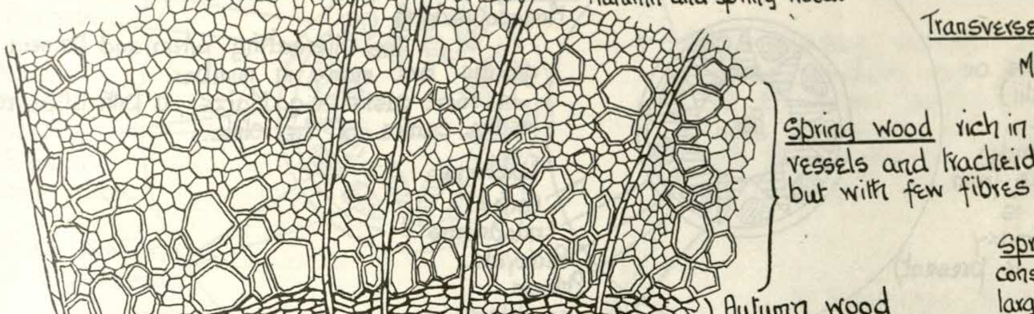
IV Second year's secondary growth.

V Third year's secondary growth.

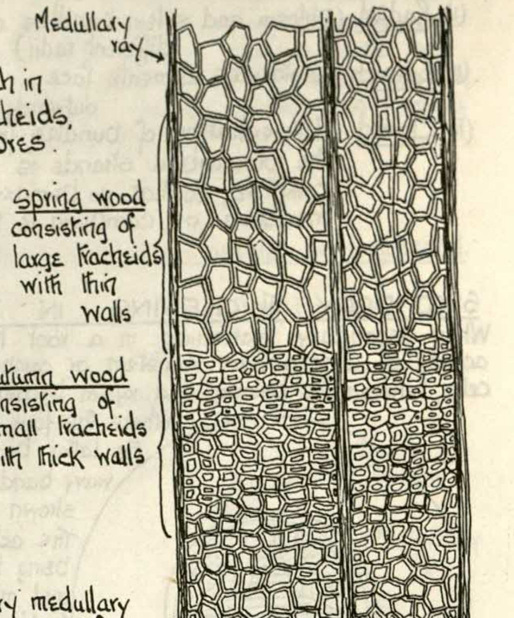


Transverse section of Angiosperm wood. e.g. Lime.

Difference between Autumn and spring wood.



Transverse section of Gymnosperm wood. e.g. Pine



The cambium being meristematic retains its power of division and so is responsible for the increase in thickness of the stem. The cells to the outside differentiate as secondary phloem, and those to the inside as secondary xylem.

In the first year of their activity certain cambial cells cut off parenchyma cells to the outside and to the inside so forming the primary medullary rays. Other cambial cells follow this procedure in the second year, having cut off secondary phloem and xylem for one year. In this way secondary medullary rays are formed. In the Autumn cambial activity lessens, while in the winter it ceases entirely.

In Monocotyledons, secondary thickening does not as a rule take place. In some, such as Dracaena, Yucca, and many Palms, which reach a large size, there is a modified form of secondary growth. Here the cambium cuts off tissue to the inside, which becomes differentiated into vascular bundles.

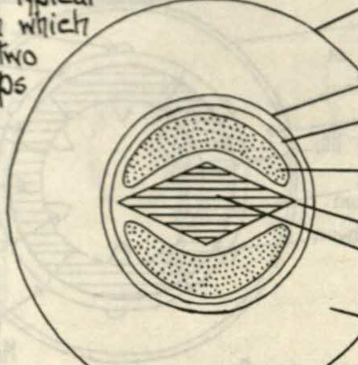
Angiosperm secondary wood contains vessels, tracheids, fibres and wood parenchyma. Gymnosperm wood contains tracheids only, hence the regularity of the wood, as compared with that of Angiosperms. In both groups, the cessation of cambial activity is responsible for the formation of "Annual rings".

M.W.M.J.

THE ROOT SYSTEM IN ANGIOSPERMS, GYMNOSPERMS AND PTERIDOPHYTA.

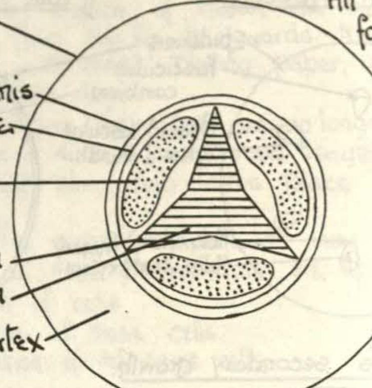
DIARCH

A condition typical of Ferns in which there are two xylem groups and two alternating bundles of phloem.



TRIARCH.

An arrangement found in the root of Pine. Here there are three xylem groups and three alternating phloem groups.

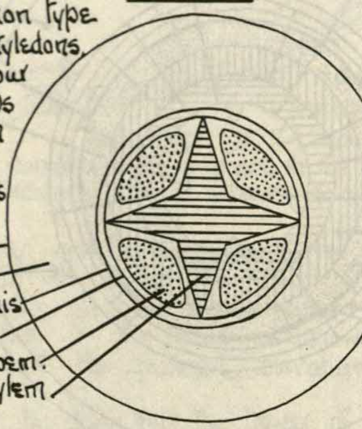


In most cases the stelar system of the root takes the form of a vascular core, which renders the root pliable - a necessary feature of an organ, which has to make its way between rough particles of soil.

For convenience they are classed together as diarch, triarch, tetrarch pentarch, polyarch according to the number of alternating xylem and phloem groups they possess.

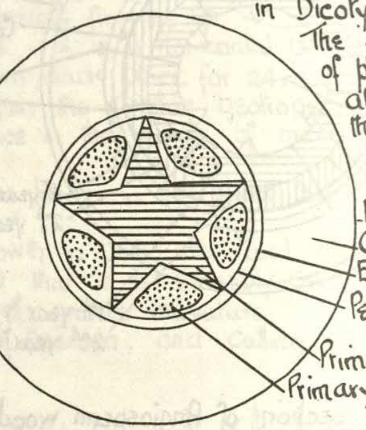
TETRARCH.

A very common type among Dicotyledons, where the four xylem groups alternate with the four phloem groups.

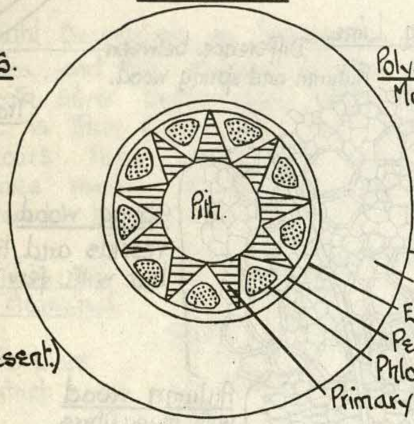


PENTARCH

Another type found in Dicotyledons. The five groups of phloem alternate with the five groups of xylem.



POLYARCH



Polyarch condition characteristic of all Monocotyledons

The alternating xylem and phloem groups are many in number.

In some cases, e.g. Maize, a pith appears in the centre of the stele.

CHARACTERISTICS OF THE ROOT BUNDLES.

Vascular bundles are:-

(I) Radial (phloem and xylem bundles on different radii)

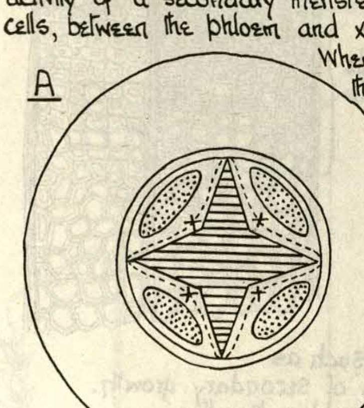
(II) Exarch (protoxylem elements face outwards)

(III) Closed (differentiation of bundles from the procambial strands is complete, so that no primary meristem or cambium is present)

SECONDARY THICKENING IN DICOTYLEDONOUS ROOTS.

When secondary thickening in a root takes place, it does so as the result of the activity of a secondary meristem or cambial layer, which arises by certain parenchyma cells, between the phloem and xylem becoming meristematic.

A

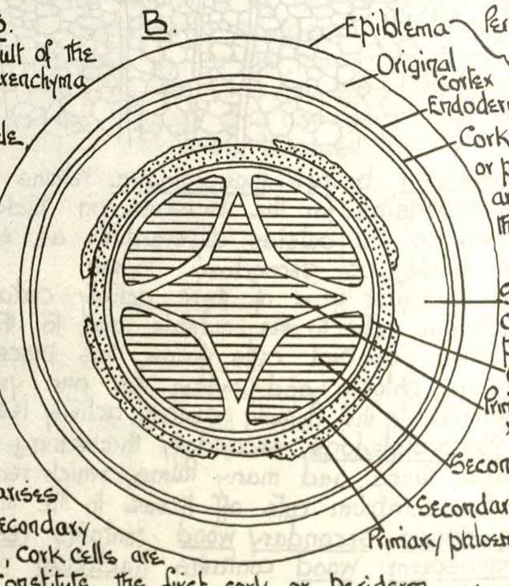


Where the four strips of cambium reach the pericycle, the latter becomes meristematic so that a wavy band of cambium is established, as shown by the dotted line.

The activity of the cambium is unequal, being least in the region of the protoxylem and most on the inner side of the phloem (indicated by X). As a result of this unequal division, cells which differentiate as secondary xylem groups are formed, so that the cambial layer becomes circular in form, after which the division of the cells is equal.

Simultaneously, the phellogen or cork cambium arises in the pericycle. To compensate for loss of cortex, a secondary cortex or phelloderm is cut off to the inside. To the outside, cork cells are formed which, in addition to the endodermis, original cortex, and epiblema, constitute the first cork or periderm.

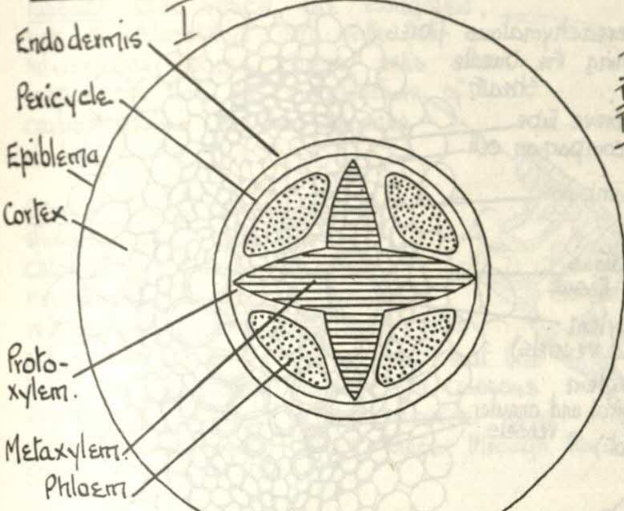
B.



M.W.M.J.

DIAGRAMMATIC TRANSVERSE SECTIONS SHOWING THE TRANSITION FROM ROOT TO STEM AS EFFECTED IN THE HYPOCOTYL.

Transverse section of the Tetrarch root.



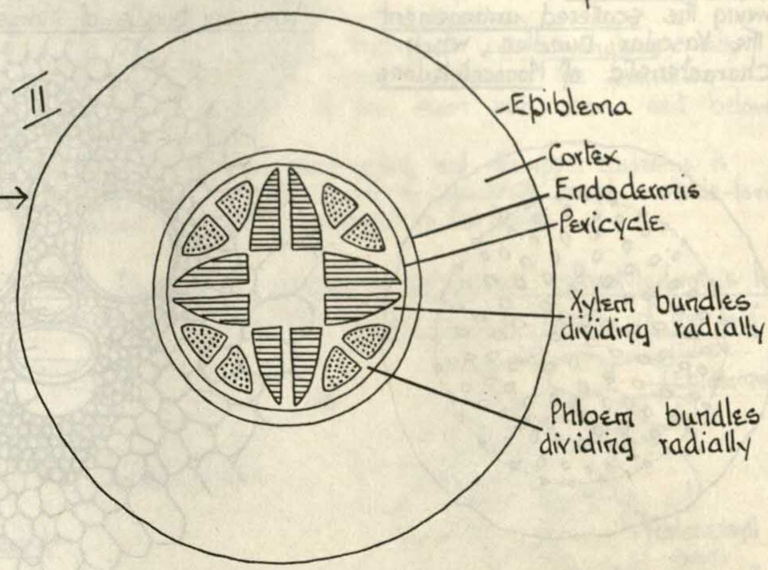
In the root the bundles have the following characteristics - They are:-

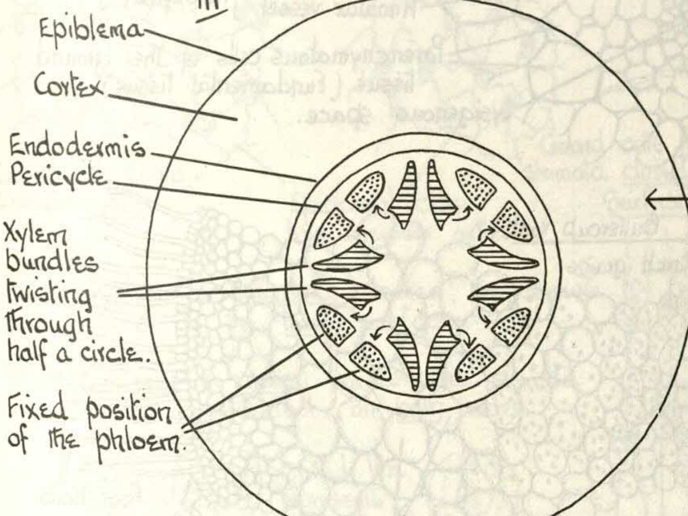
I Radially arranged (xylem and phloem bundles on different radii)
II Exarch (protoxylem elements face outwards)
III Closed (No cambium or primary meristem is present, the differentiation of the procambial strands being complete)

Lateral branches of the root arise endogenously taking their origin from the pericycle in a position either opposite each protoxylem group, or opposite to the parenchyma strands between the phloem and the xylem groups.

This mode of origin means that the root is well-matured before it emerges from the cortex and therefore unlikely to be damaged when it makes its way between the particles of soil.

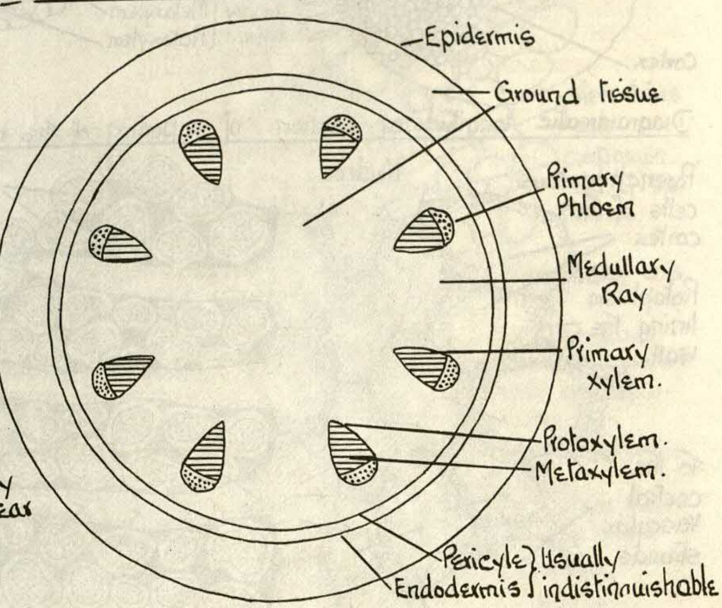
At this stage, the xylem and phloem bundles are dividing radially, so that the number of xylem and phloem groups are doubled.





After dividing radially the phloem groups retain their former position with the protophloem facing outwards, but the xylem bundles twist through half a circle and come to lie on the inner side of the phloem groups, with the protoxylem elements facing inwards, so forming the collateral bundle typical of the stem.

IV Transverse section of the Plumule or Hypocotyl.



In the Hypocotyl or Plumule the characteristic stem structure is evident.

Stem bundles differ from root bundles in that they are:-

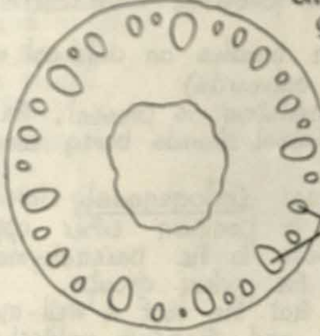
I Conjoint or Collateral (xylem and phloem bundles, are on the same radius)
II Endarch (protoxylem elements face inwards)
III Open. (A cambium or primary meristem is present between the phloem and xylem, the differentiation of the procambial strands being complete.)

Branches of the shoot system arise exogenously, taking their origin superficially, so that they are relatively immature when first they appear as prominences from the epidermis.

M.W.M.J.

ANGIOSPERM STEM AND ROOT. INTERNAL STRUCTURE.

Diagram of transverse section of Buttercup stem (Ranunculus) showing the ring-like arrangement of the vascular bundles which is typical of Dicotyledons



Vascular bundle of Buttercup.

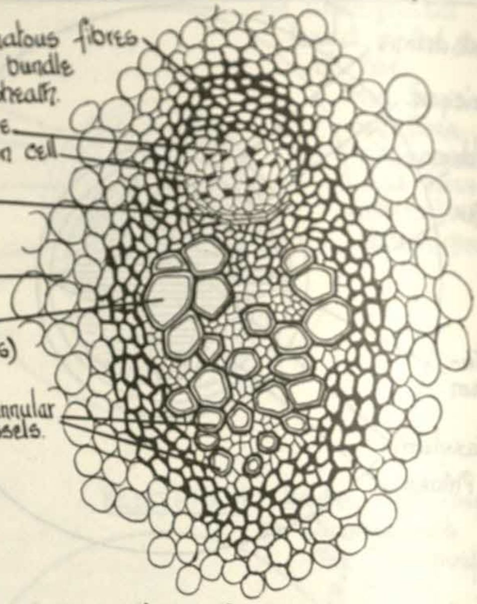
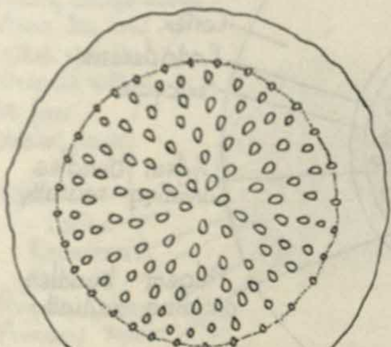


Diagram of the transverse section of Butcher's Broom (Ruscus) showing the scattered arrangement of the vascular bundles, which is characteristic of Monocotyledons.



Vascular bundle of Maize (Monocot.)

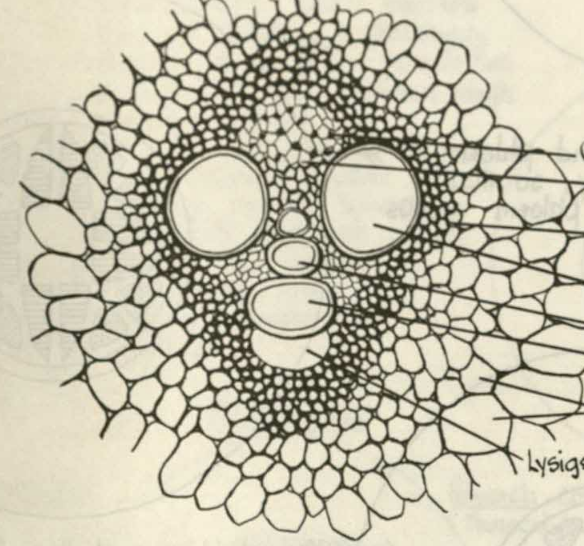
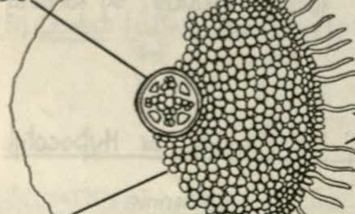
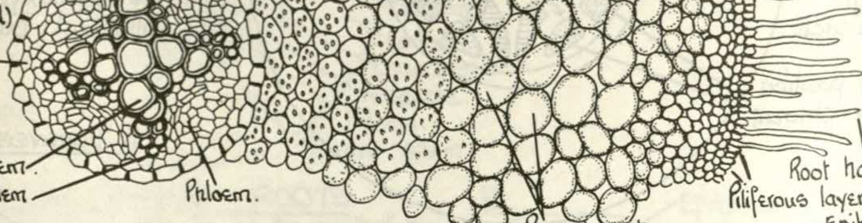


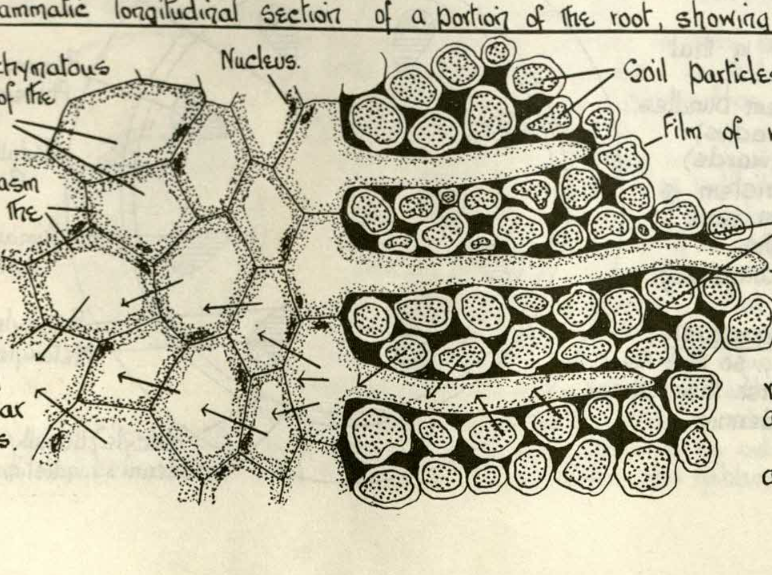
Diagram of transverse section of Buttercup (Ranunculus) root.



Central vascular core of Buttercup root.



Diagrammatic longitudinal section of a portion of the root, showing the root hairs in relation to the soil particles.

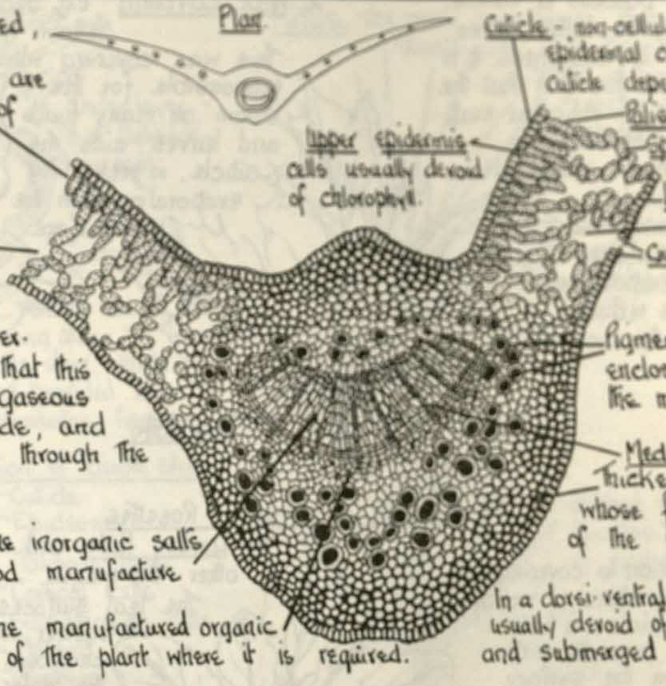


The carbon dioxide given off during the respiration of the root dissolves in the water and forms a dilute acid. This readily dissolves necessary salts in the soil which otherwise are insoluble in pure water.

M.W.M.J.

LEAF STRUCTURE – MONOCOTYLEDONS AND DICOTYLEDONS.

Transverse section of a dorsiventral or horizontal mesophytic dicotyledonous Leaf.



Palisade cells which are elongated, rich in chlorophyll, and with few intercellular spaces. These cells are responsible for the manufacture of carbohydrates in the presence of light

Cuticle - non-cellular secretion of the upper epidermal cells. Upon the thickness of the cuticle depends the rate of evaporation

Palisade tissue } Mesophyll.
Spongy tissue

Lower epidermis

Intercellular spaces.

Guard cells of the stoma, which are rich in chloroplasts

Spongy tissue of irregular stellate cells, with few chlorophyll grains. The irregularity of their outline is responsible for the abundant intercellular spaces, with the result that this tissue is especially suitable for gaseous interchange, (oxygen, carbon dioxide, and water vapour) which takes place through the stomata

Pigment-containing cells which enclose the vascular bundle of the mid-rib.

Medullary ray

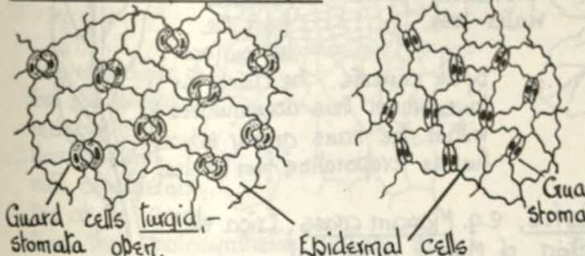
Thickened (collenchymatous) cells whose function is the protection of the main vein, above and below.

Xylem or wood, which carries the inorganic salts in solution to the leaves for food manufacture

Phloem or bast which carries the manufactured organic food from the leaf to any part of the plant where it is required.

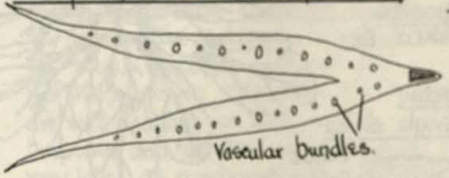
In a dorsi-ventral leaf the upper epidermis is usually devoid of chlorophyll, except in shade-loving and submerged water plants.

Surface view of the epidermis of a dicotyledonous leaf, showing the distribution of the stomata.

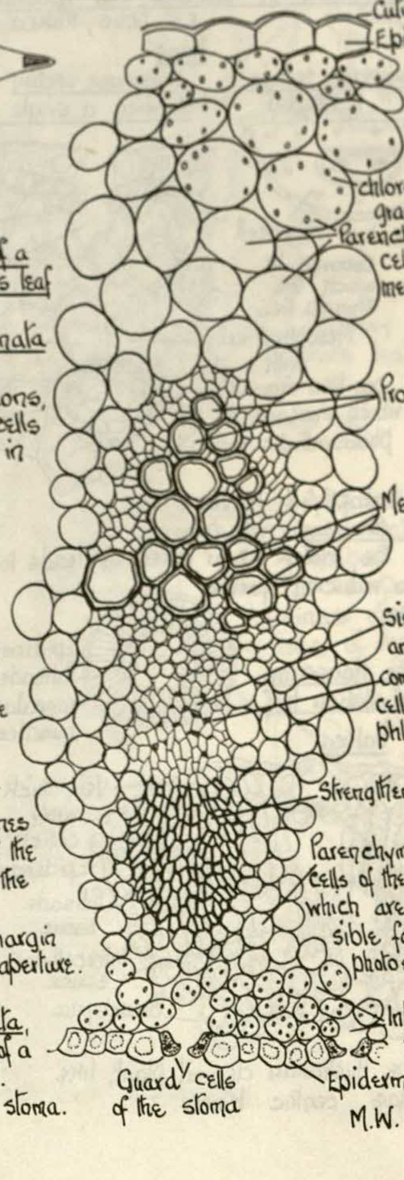


Transverse section through a vertical or isobilateral monocotyledonous leaf

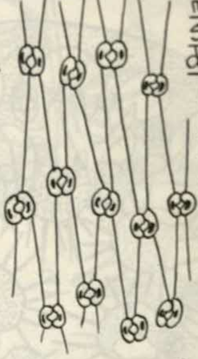
Plan of transverse section of Iris leaf



Single vascular bundle of Iris leaf.



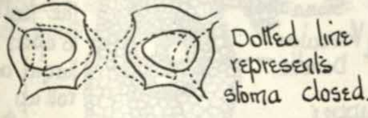
Surface view of the epidermis of a monocotyledonous leaf showing the distribution of stomata



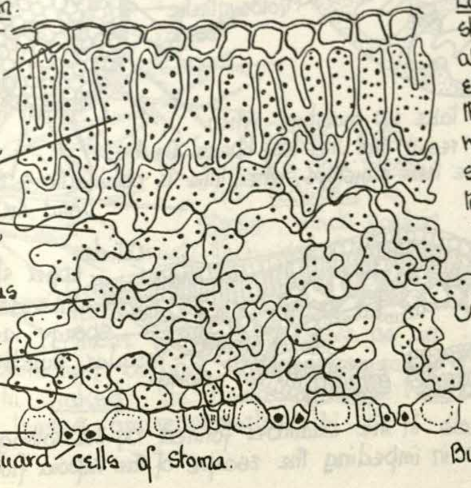
In monocotyledons, the epidermal cells are elongated in surface view.

In dorsiventral or horizontal leaves, the stomata are confined to the lower surface.

In isobilateral or vertical leaves, the stomata are equally distributed on both sides.



Transverse section of the dorsiventral leaf of Lilium.



Each stoma consists of two bean-shaped guard cells, enclosing the aperture between them. The concave edge of each cell is less elastic than the outer convex margin, with the result that the latter stretches first when the cell becomes turgid, drawing with it the rest of the guard cell and so widening the aperture.

When flaccid, the convex margin shrinks first and so closes the aperture.

To locate the position of the stomata, wax the cut end of the petiole of a leaf and plunge into warm water. Bubbles mark the position of each stoma.

M.W.M.J.

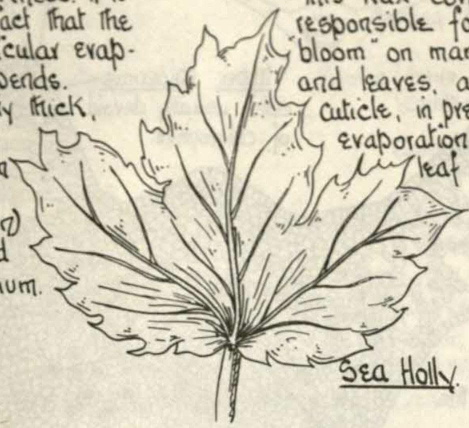
24. MODIFICATIONS OF THE SHOOT FOR WATER ECONOMY AND PROTECTION.

1. Thick Cuticle
e.g. Ivy. etc.

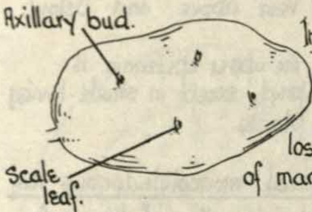
Although all leaves possess a cuticle, the latter varies in thickness. It is upon this fact that the rate of cuticular evaporation depends. When very thick, cuticular transpiration (surface evaporation) is reduced to the minimum.

2. Wax covering
e.g. Sea Holly, Cabbage, Yellow Horn Poppy etc.

This wax covering which is responsible for the "bloom" on many fruits and leaves, aids the cuticle, in preventing evaporation from the leaf surface.



3. Cork covering
e.g. Potato



In addition to covering the aerial stems of woody perennials, a cork layer prevents water loss from the surface of many underground stems.

4. Massing of leaves in Rosettes.
e.g. London Pride and other Saxifrages.

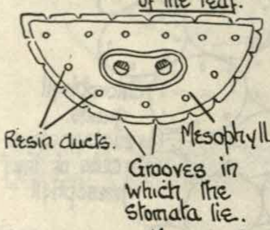
The leaf surfaces are close together, and so form chambers in which the water vapour given off tends to accumulate, thus preventing further water loss.

5. Dense covering of Hairs
e.g. Lamb's Ear.

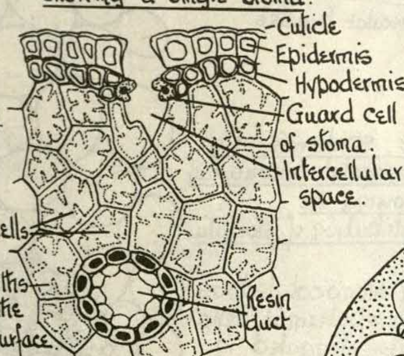
Hairs serve to impede the escape of water vapour which is normally removed from the leaf surface by air currents. The damp air layer which thus accumulates within the hairs greatly reduces further evaporation from the leaf.

6. Depression of stomata into grooves.
e.g. Pinus, Hakea etc.

Pinus
Plan of transverse section of the leaf.

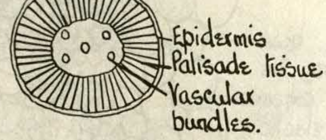


Pinus.
Transverse section showing a single stoma.

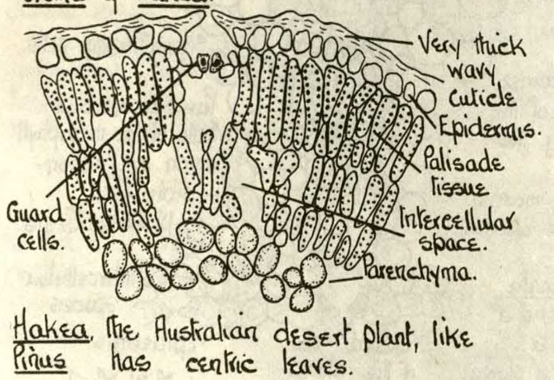


In many xerophytic leaves, the stomata are sunk into grooves, in which the water vapour given off tends to collect, so reducing further water loss.

Plan of the transverse section of Hakea leaf

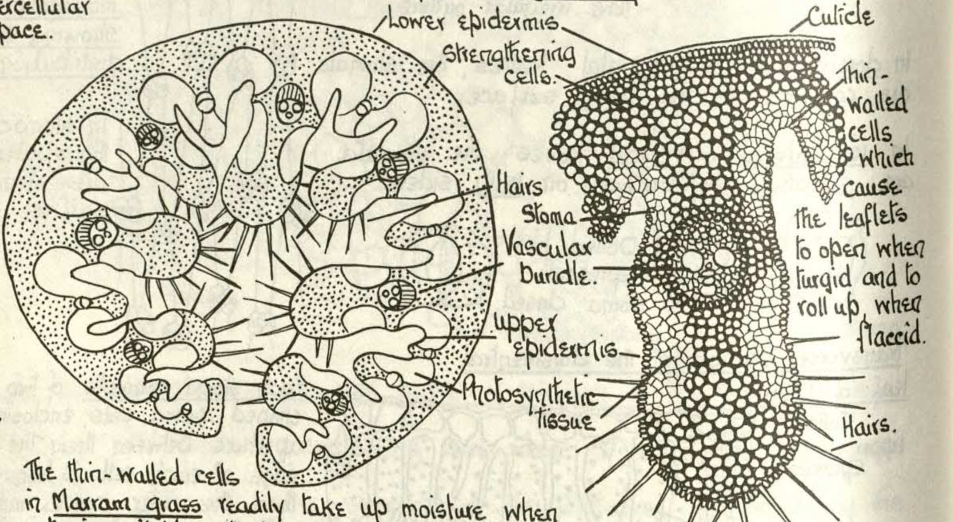


Stoma of Hakea.



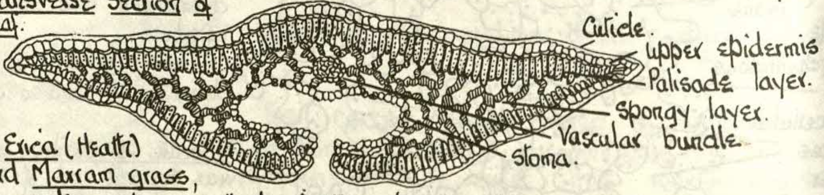
Hakea, the Australian desert plant, like Pinus has centric leaves.

7. Rolled leaves, e.g. Marram grass, Erica etc.
Transverse section of Marram grass leaf.



The thin-walled cells in Marram grass readily take up moisture when water is available, with the result that the leaf opens. On the other hand, they soon lose their moisture when little is obtainable, so that they shrink, and the leaf closes.

Transverse section of Erica leaf.



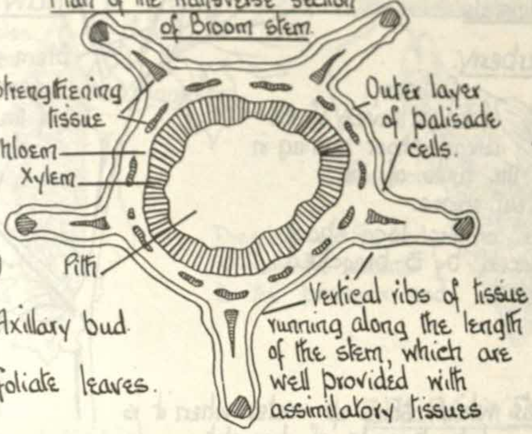
In Erica (Heath) and Marram grass, the water vapour collects in the chamber formed by the rolling of the leaf. The hairs further assist in impeding the escape of the vapour from the chamber.

M.W.M.J.

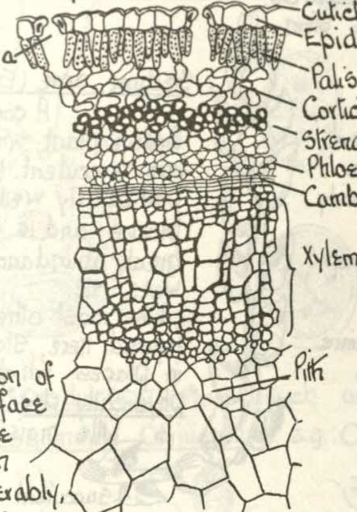
8. Reduction of the Leaf surface.

Broom.

Plan of the transverse section of Broom stem.



Portion of the transverse section of Broom stem.

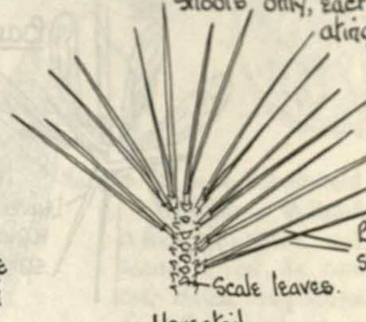


The reduction of the leaf surface reduces the transpiration rate considerably, but at the same time the photosynthetic surface is lessened.

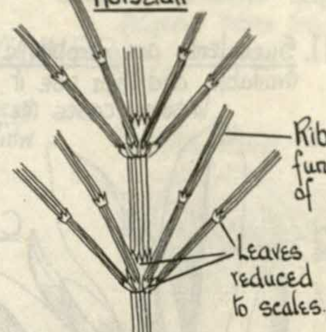
This difficulty is overcome by the stem becoming assimilatory as in Broom, Horsetail and Bilberry.

The stems are green, with closely packed assimilatory tissue towards the outside, and are furrowed or winged, so as to increase the photosynthetic surface.

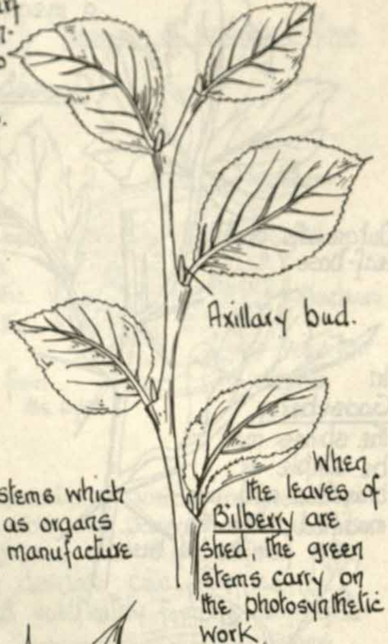
Pinus. The main axis bears dwarf shoots only, each terminating in two centric leaves.



Horsetail



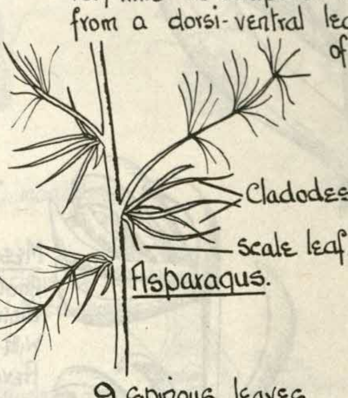
Bilberry.



When the leaves of Bilberry are shed, the green stems carry on the photosynthetic work.

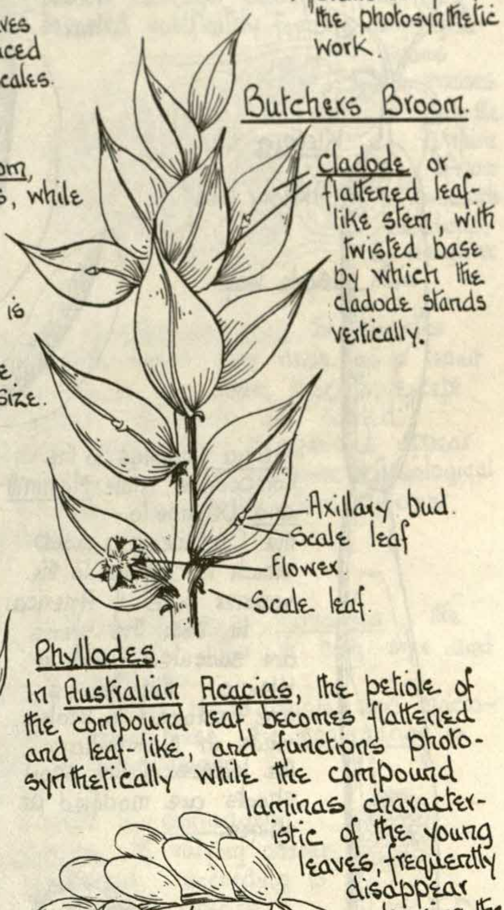
Cladodes.

In Asparagus and Butcher's Broom, the leaves are reduced to scales, while the stems become flattened and leaflike, forming cladodes. These are well adapted for assimilatory purposes, and yet their water loss is very little as compared with that from a dorsi-ventral leaf surface of similar size.



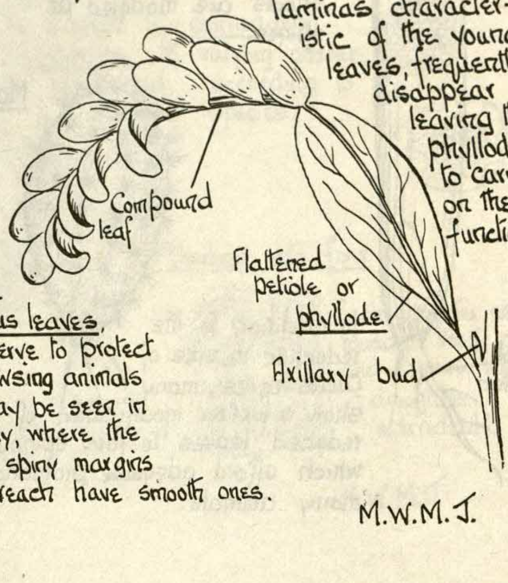
Asparagus.

Butchers Broom.



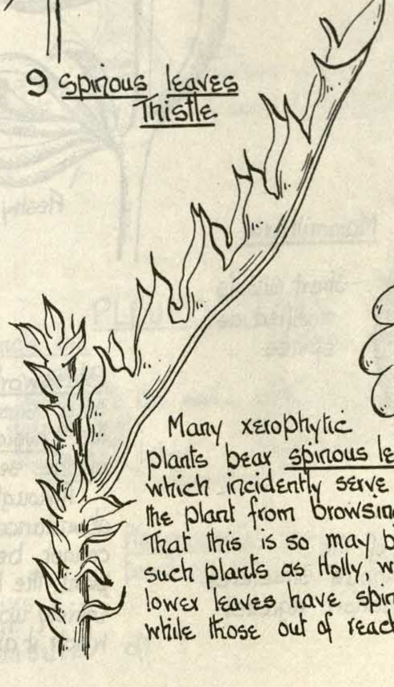
Phyllodes.

In Australian Acacias, the petiole of the compound leaf becomes flattened and leaf-like, and functions photosynthetically while the compound laminas characteristic of the young leaves, frequently disappear leaving the phyllodes to carry on their functions



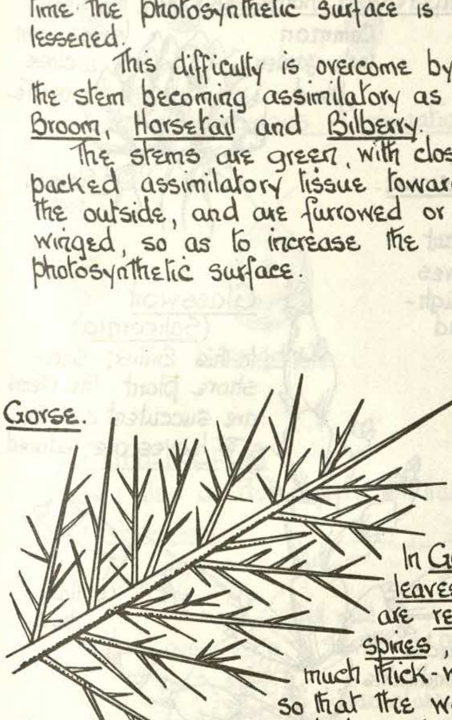
9 Spinous leaves

Thistle



Many xerophytic plants bear spinous leaves, which incidently serve to protect the plant from browsing animals. That this is so may be seen in such plants as Holly, where the lower leaves have spiny margins while those out of reach have smooth ones.

Gorse.



In Gorse, both leaves and stems, are reduced to spines, which contain much thick-walled tissue, so that the water-loss is reduced to a minimum.

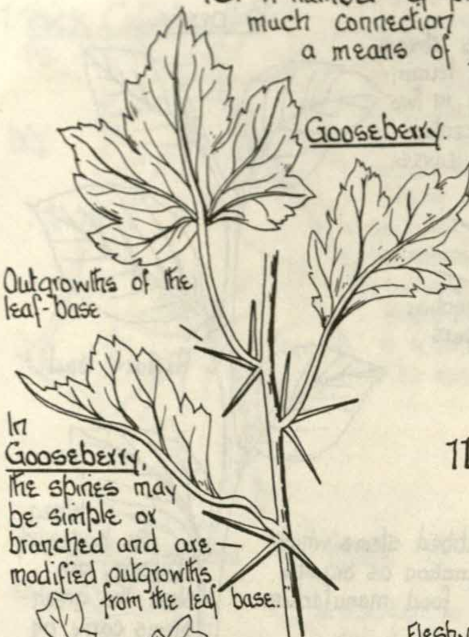
These spines also serve as an adequate protection against browsing animals.

In Hakea, the Australian desert plant the leaves are represented by stiff spines.

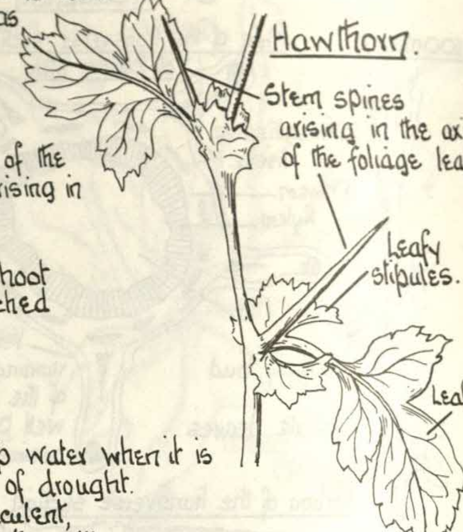
M.W.M.J.

MODIFICATIONS OF THE SHOOT FOR WATER ECONOMY AND PROTECTION.

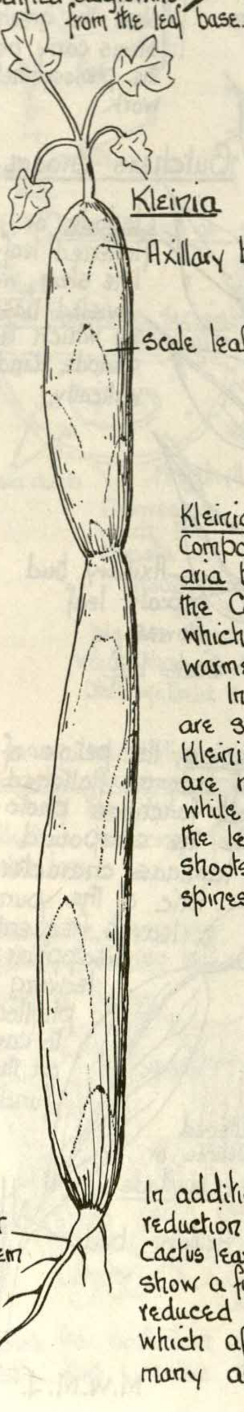
10. A number of plants produce spines which do not appear to have much connection with water loss, but probably serve mainly as a means of defence against browsing animals.

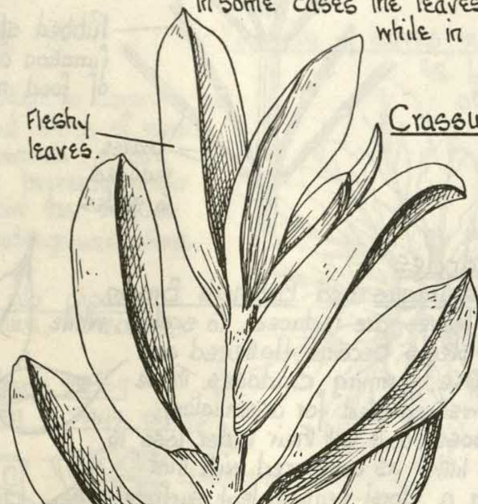


In Gooseberry, the spines may be simple or branched and are modified outgrowths from the leaf base.

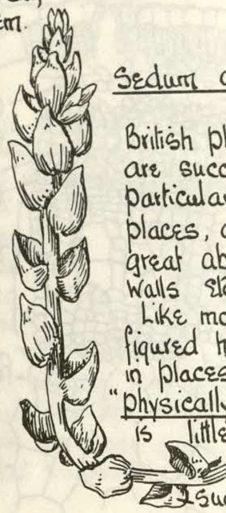


11. Succulents are xerophytic plants which store up water when it is available, and then use it during later periods of drought. In some cases the leaves alone are succulent, while in others it is the stem.





A leaf succulent which belongs to the same family as does the English stonecrop. This South African plant forms large mimic stones by its globular form.

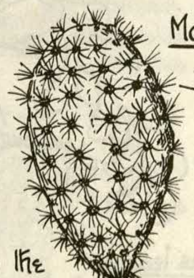


Sedum acre (Stonecrop)
A common British plant, whose leaves are succulent. It thrives particularly well in dry rocky places, and is found in great abundance on stone walls etc.
Like most other succulents figured here, Stonecrop lives in places which are "physically dry" (where there is little moisture) - e.g. deserts etc

Kleinia belongs to the Compositae, while Mammillaria belongs to the Cactaceae, a group which is confined to the warmer parts of America. In both, the stems are succulent, and in Kleinia the leaves are reduced to scales, while in Mammillaria the leaves of the short shoots are modified as spines.

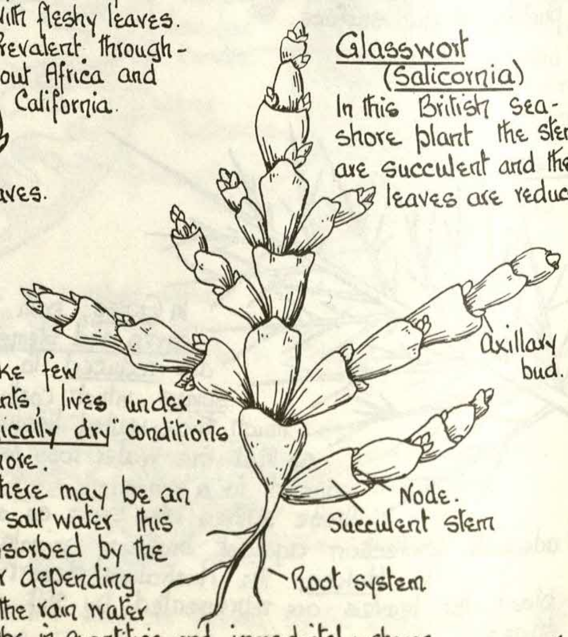
Sempervivum (Houseleek) Here the fleshy leaves form a close rosette.
Common rock-garden plant.

Mesembryanthemum. Another widely distributed plant with fleshy leaves. Prevalent throughout Africa and California.



In addition to the reduction in size of Cactus leaves, many show a further modification of the reduced leaves to form spinous structures which afford adequate protection against many animals.

Glasswort (Salicornia)
In this British sea-shore plant the stems are succulent and the leaves are reduced



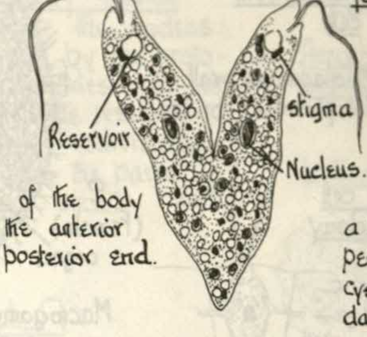
Glasswort like few other succulents, lives under the "physiologically dry" conditions of the seashore.
Although there may be an abundance of salt water this cannot be absorbed by the plant, the latter depending entirely upon the rain water which it absorbs in quantities and immediately stores.

M.W.M.J.

EUGLENA

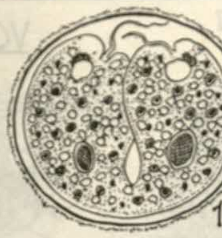
Mature Individual

Asexual Reproduction
Longitudinal fission of free-swimming form.

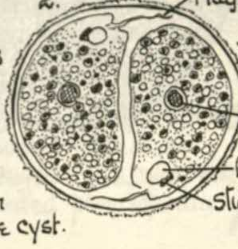


Division of the body is from the anterior to the posterior end.

Asexual Reproduction.
Division of encysted form.

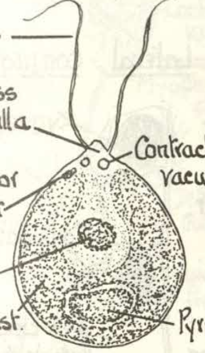


Prior to encystment, Euglena withdraws its flagellum and forms a thick gelatinous wall. After a period of rest, the contents of the cyst divide longitudinally, and the daughter individuals acquiring flagella make their way from the cyst.

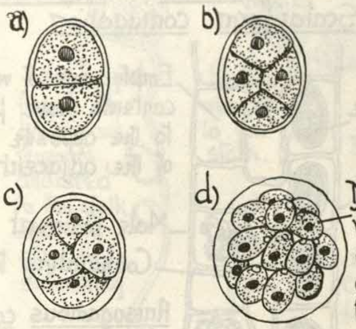


CHLAMYDOMONAS

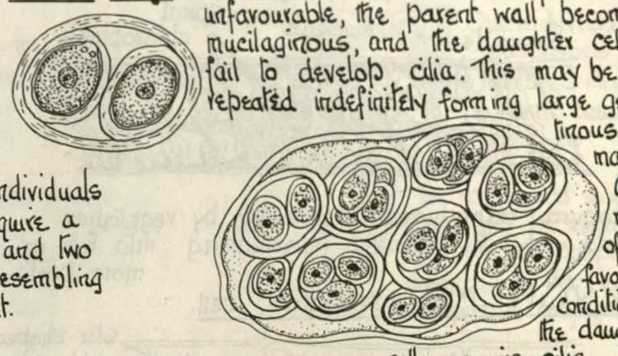
Mature Individual.



Asexual Reproduction.

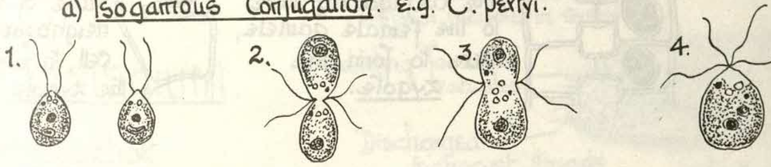


Palmella stage. Under conditions which are probably unfavourable, the parent wall becomes mucilaginous, and the daughter cells fail to develop cilia. This may be repeated indefinitely forming large gelatinous masses. On the return of more favourable conditions, the daughter cells acquire cilia.



Sexual Reproduction. (From Fritsch and Salisbury)

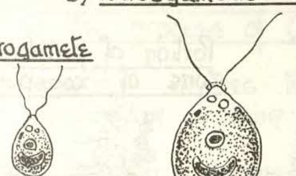
a) Isogamous Conjugation. e.g. C. pertyi.

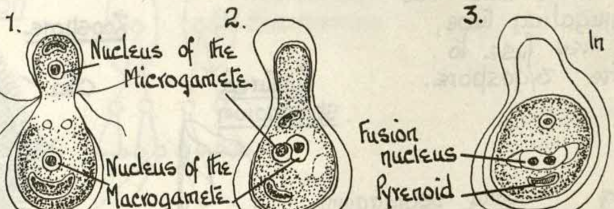


In most species of Chlamydomonas, the gametes are alike and mostly naked. They arise as a result of segmentation, as in the above process, except that more daughter individuals are formed.

In isogamous conjugation, the gametes appear similar, although there must be some physiological difference, as only the gametes from different parent individuals conjugate.

b) Anisogamous Conjugation e.g. C. monadina.

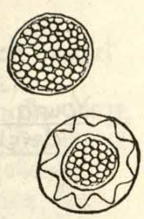




In Chlamydomonas monadina, the gametes differ in both size and behaviour.

When microgamete and macrogamete fuse, the conjugation is anisogamous.

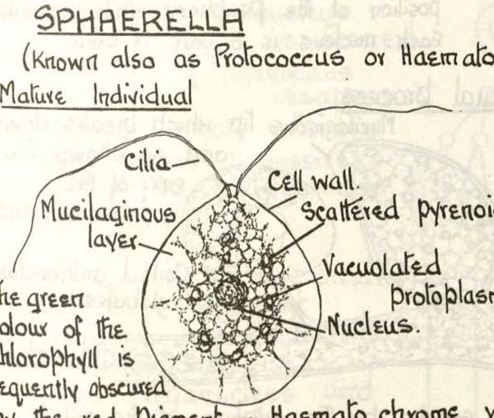
As a result of conjugation a zygospore of varying character is formed, according to the species.



SPHAERELLA

(Known also as Protococcus or Haematococcus)

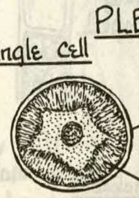
Mature Individual



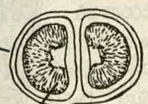
The green colour of the chlorophyll is frequently obscured by the red pigment - Haemato chrome, which occurs particularly in the resting stage when the cilia are withdrawn and the individuals round themselves off

PLEUROCOCCUS

Single cell



Dividing into two



Pleurococcus forms a green powdery mass on tree-trunks etc.

Dividing into four.

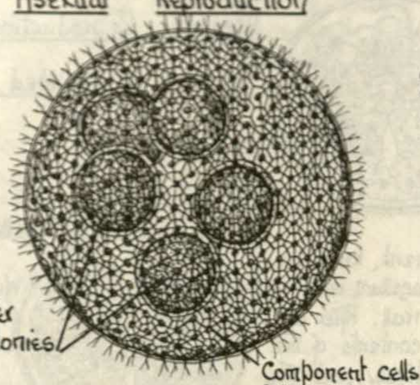
Each daughter cell rounds itself off and grows into a daughter individual.

M.W.M.J.

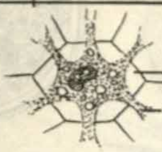
THALLOPHYTA (continued) STRUCTURE and REPRODUCTION.

VOLVOX

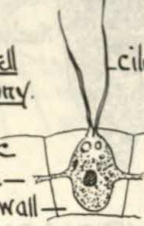
Asexual Reproduction



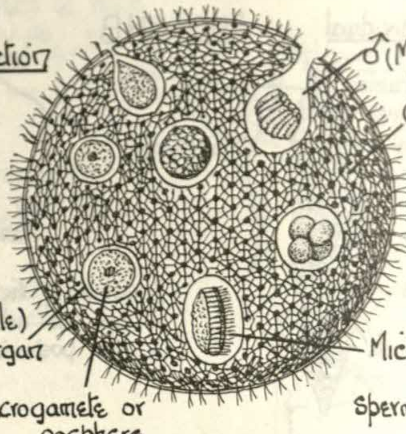
Surface view of component cell.



A single cell of the colony.



Sexual Reproduction



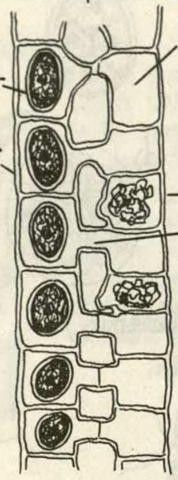
SPIROGYRA.

Vegetative cell of Spirogyra.

Spirogyra reproduces asexually by vegetative means only, the filament fragmenting into two or more parts.

Sexual Reproduction

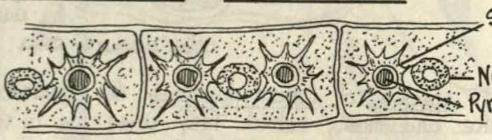
Scalariform conjugation



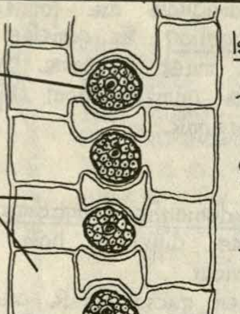
Anisogamous conjugation
The gamete of the male filament passes through the conjugating tube to the female gamete, there to form the zygote.

Lateral conjugation

ZYGNEMA. Vegetative cell.



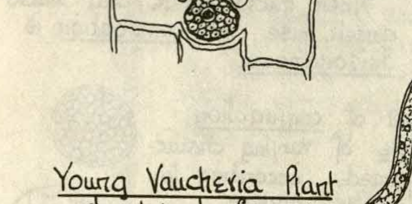
Sexual Reproduction



Isogamous conjugation.
The protoplasm of the cells acts as gametes, and pass at the same time into the conjugating tube, where they fuse to form the zygospore.

VAUCHERIA

Young Vaucheria Plant developed from the Zoospore

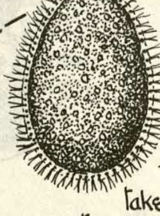


Young sporangium

In the formation of the zoospore, the tip of the branch becomes swollen and cut off from the filament by a cross-wall to form the Zoosporangium.

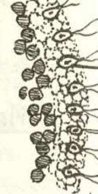
Ruptured sporangium

Zoospore

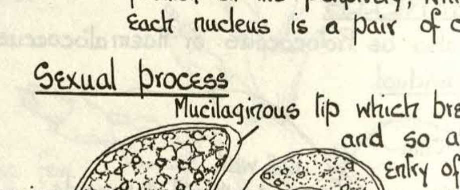


The nuclei take up their position at the periphery, while opposite each nucleus is a pair of cilia.

Portion of peripheral zone of zoospore.



Sexual process



Spermatozoid

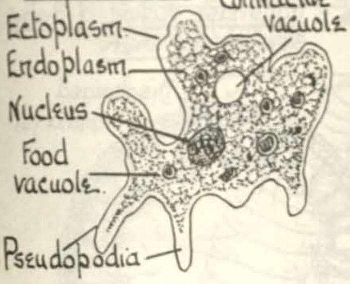
The biciliate spermatozoids escape by the rupture of the coiled antheridium. One enters the Oogonium, where it fuses with the oosphere to form the Oospore.

M.W.M.J.

PROTOZOA. STRUCTURE and REPRODUCTION.

AMŒBA

Surface view.



Asexual Reproduction.

1. Binary fission
Here the nucleus followed by the protoplasm divides into two halves. The resulting daughter individuals resemble the parent in all but size.

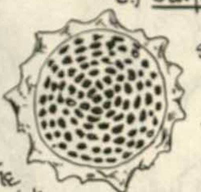
2. Multiple fission or Spore formation

a) Amœba Encysted

b). Section of the cyst.

Nucleus of the cyst divides into a large number of small nuclei which pass to the surface of the protoplasm

c.) Surface view of the cyst.

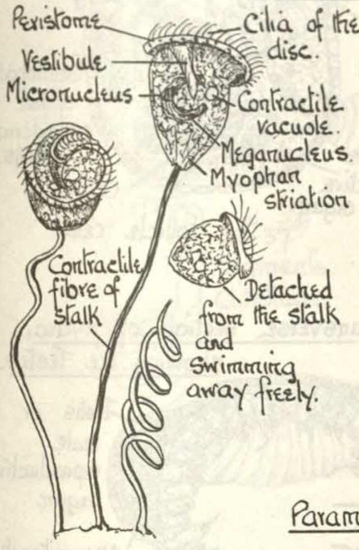


Each daughter nucleus surrounded by a portion of peripheral protoplasm forms the daughter individuals or spores

d.) Spore

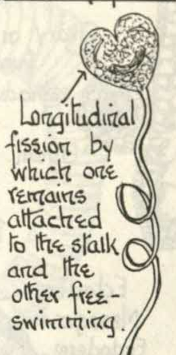
On escaping, the spores appear as perfect Amœbulas with pointed pseudopodia.

VORTICELLA



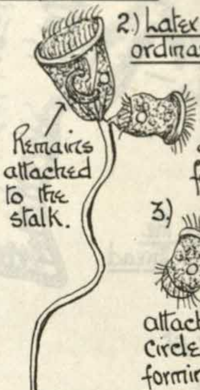
Asexual Reproduction

1.) Ordinary fission



Longitudinal fission by which one remains attached to the stalk and the other free-swimming.

2.) Later stage of ordinary fission.



Later becomes detached after forming an aboral circle of cilia

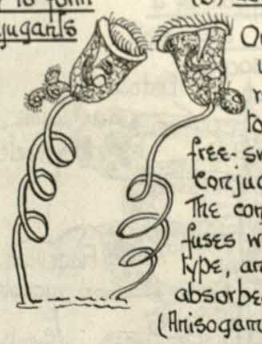
3.)

After swimming freely, it becomes attached by the aboral circle of cilia, later forming a stalk.

Vorticella - Sexual reproduction.

(a) Fission to form Conjugants

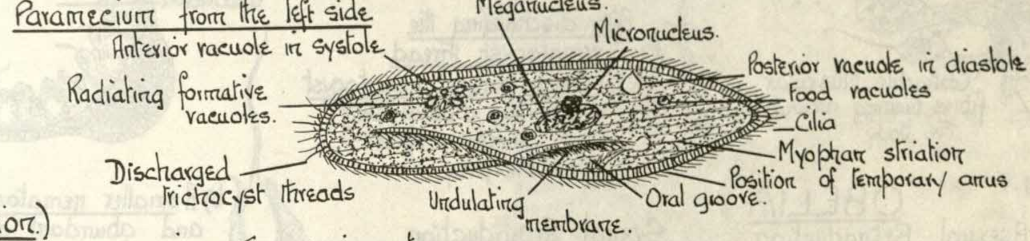
(b) Conjugation.



One individual undergoes repeated division to form small free-swimming conjugants. The conjugant so formed fuses with the normal type, and is completely absorbed by the latter. (Anisogamous conjugation)

PARAMECIUM.

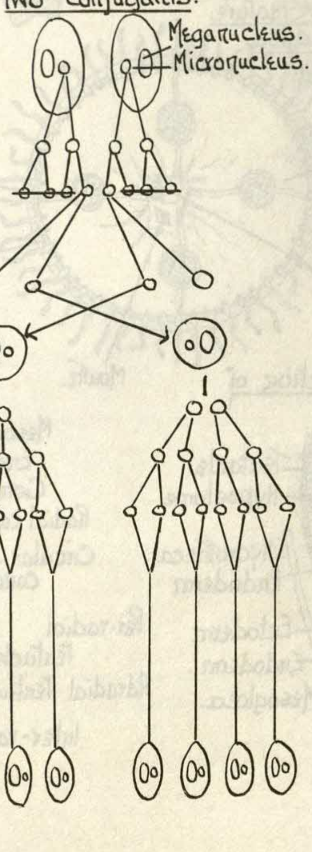
Paramecium from the left side



Reproduction (Isogamous conjugation.)

Behaviour of the Micronuclei during the process of Conjugation

Two conjugants.



Micronucleus divides twice
Reduction division (Meiosis)

Three resulting segments disappear.

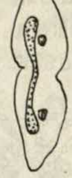
Fourth remaining segment divides into a large female pronucleus and small male pronucleus.

Zygote is formed. (Meganucleus disappears).

Resulting zygote divides three times successively so that the body contains eight nuclei

Each conjugant now divides twice, each segment containing two nuclei which differentiate into one meganucleus and one micronucleus.

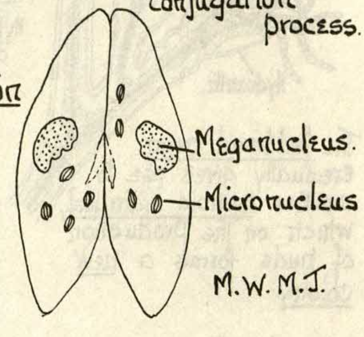
1. In Binary transverse fission



Under favourable conditions this happens two or three times a day.

In Depression.
A condition which might be regarded as old age. The meganucleus is abnormally large and the body stunted. Death of the organism frequently follows. In its early stages, it precedes the conjugation process.

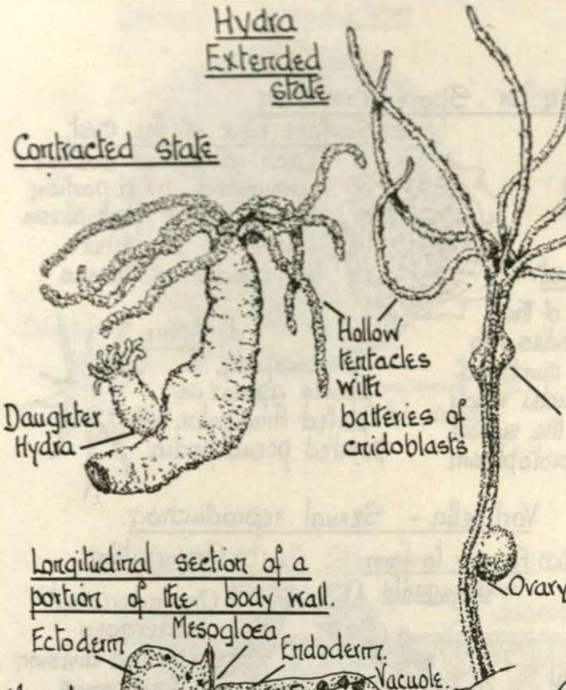
3 In Conjugation



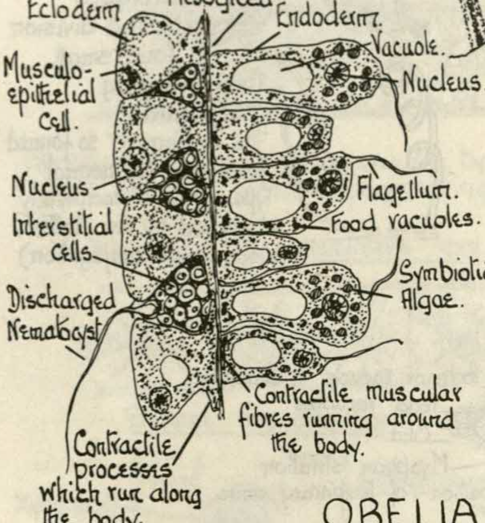
M.W.M.J.

30. CŒLENTERATA - STRUCTURE and REPRODUCTION

HYDRA

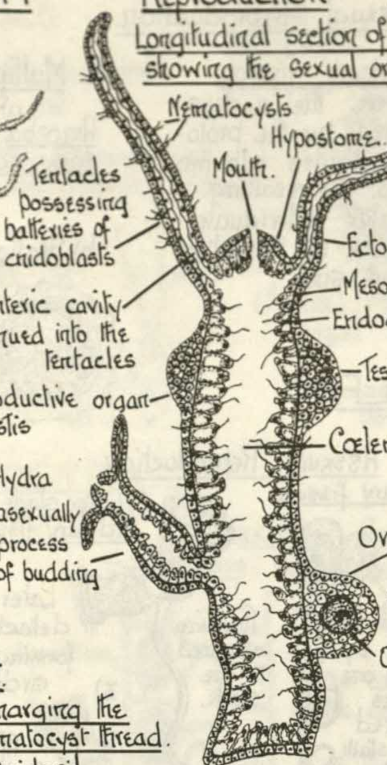


Longitudinal section of a portion of the body wall.

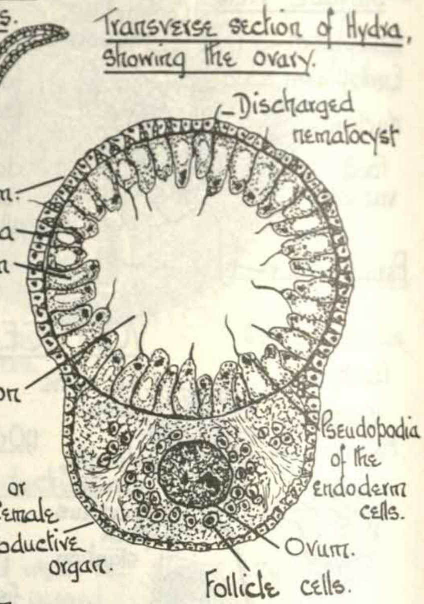


Reproduction - Asexual and sexual.

Longitudinal section of Hydra, showing the sexual organs.

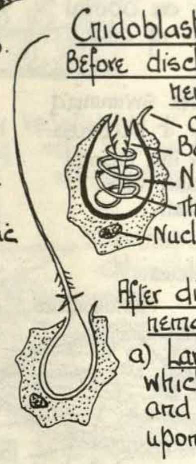


Transverse section of Hydra, showing the ovary.



Cnidoblast.

Before discharging the nematocyst thread.

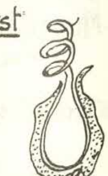


After discharging the nematocyst thread

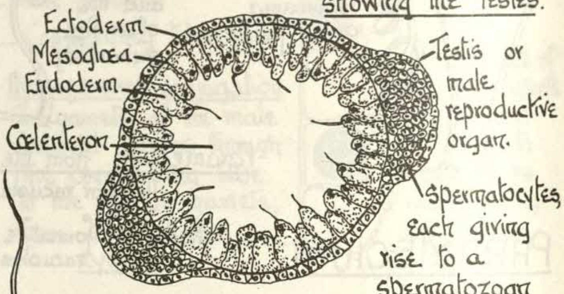
a) Large barbed nematocyst which has a paralysing and numbing effect upon the prey.

b) A smaller nematocyst without barbs and abundant on the tentacles. Used for the attachment of the tentacles to the prey or other objects.

c). A spiral nematocyst which is very efficient in entangling the prey.



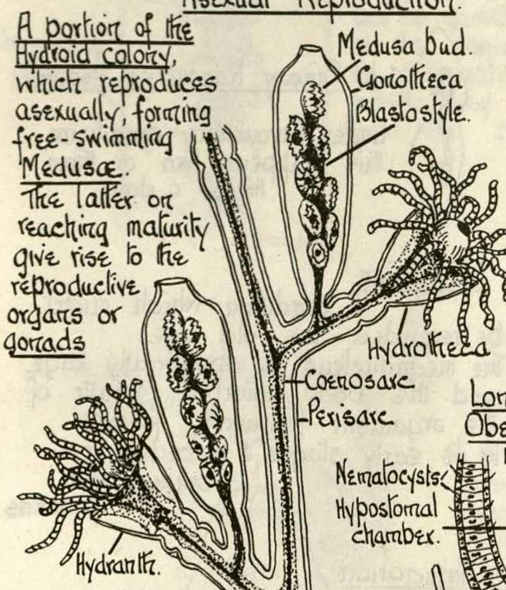
Transverse section of Hydra, showing the Testes.



OBELIA

Asexual Reproduction.

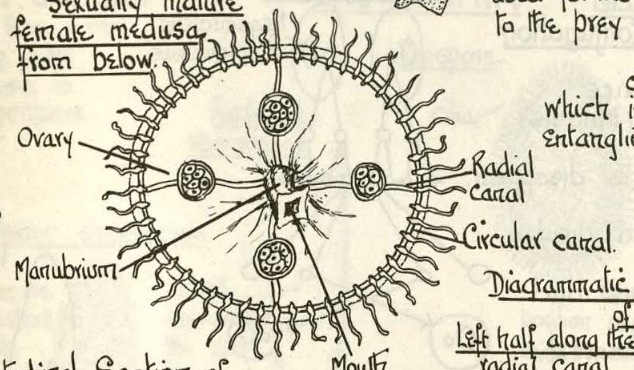
A portion of the Hydroid colony, which reproduces asexually, forming free-swimming Medusae. The latter on reaching maturity give rise to the reproductive organs or gonads



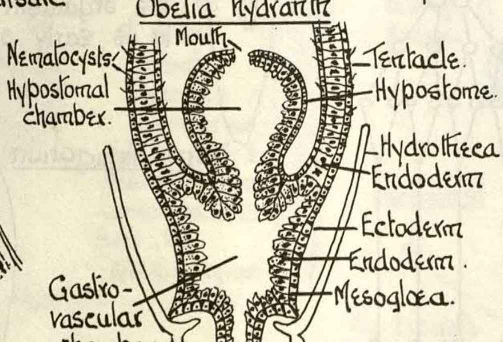
The fertilised ovum eventually gives rise to another hydroid individual, which on the production of buds forms a new colony.

Sexual Reproduction

Sexually mature female medusa from below.

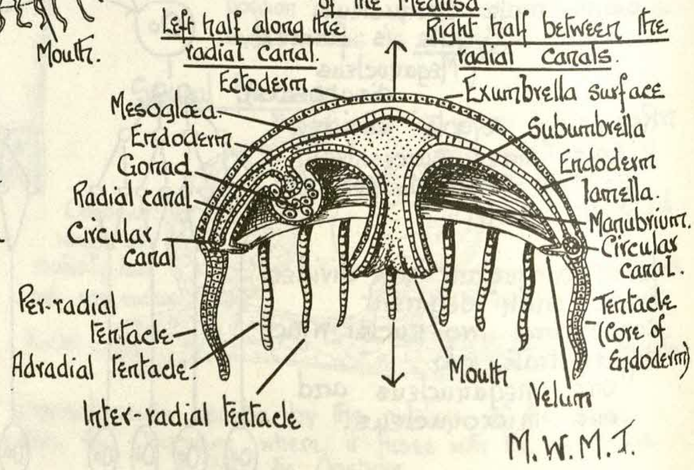


Longitudinal Section of Obelia hydranth



Diagrammatic Longitudinal Section of the Medusa.

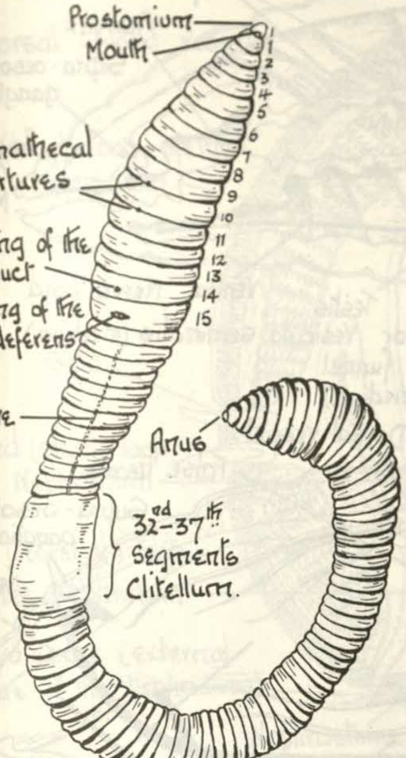
Left half along the radial canal. Right half between the radial canals.



M. W. M. T.

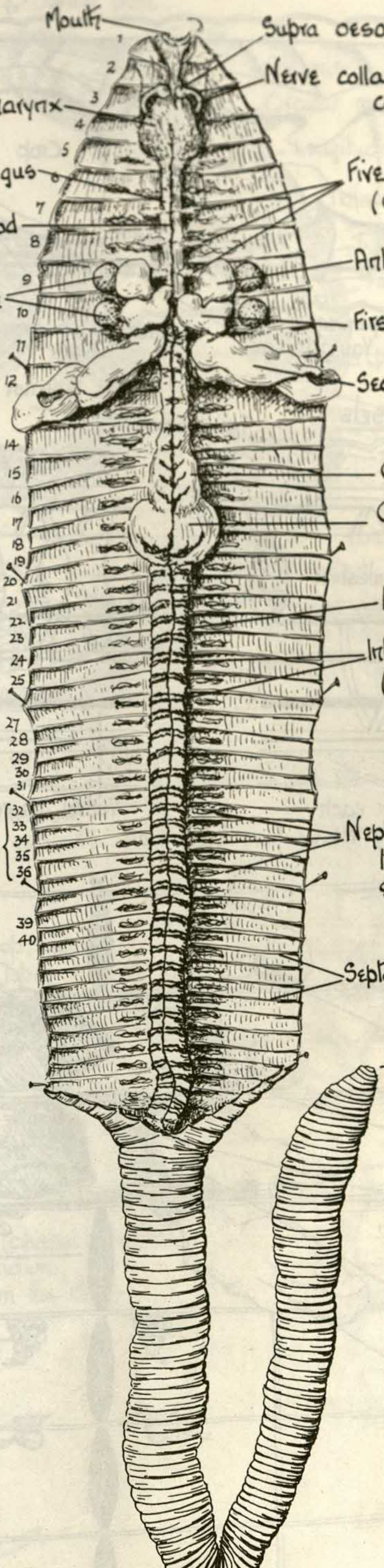
LUMBRICUS TERRESTRIS - EARTHWORM.

External features. Turned slightly to one side in order to show the Genital pores.



Worms in Coition

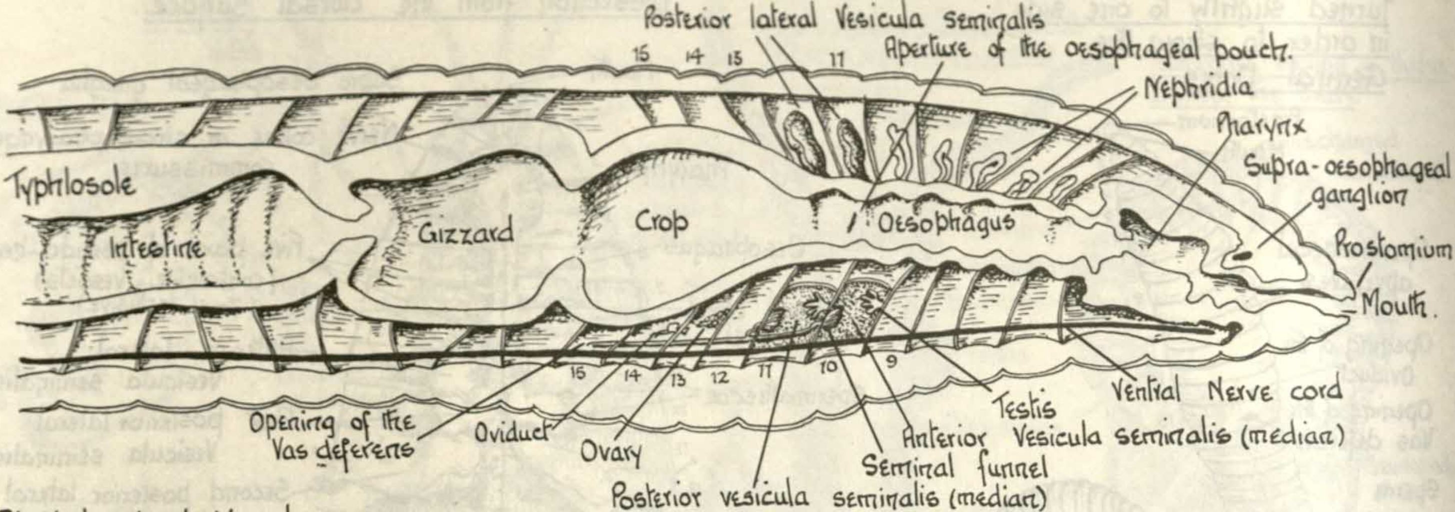
Dissection from the dorsal surface.



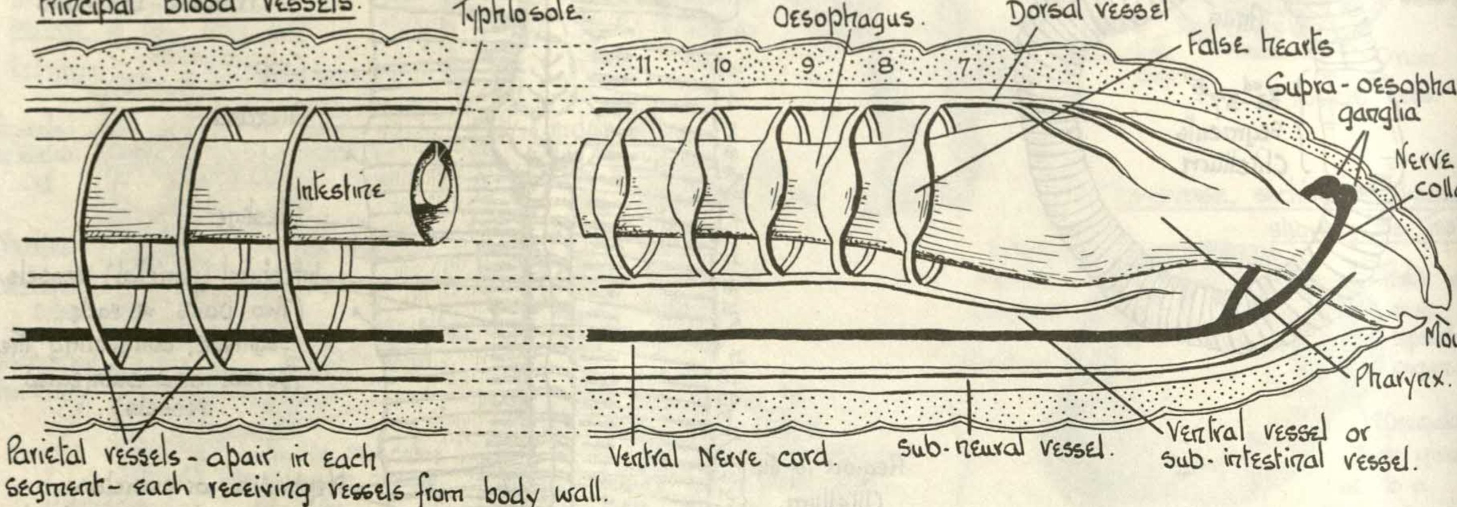
M.W.M.J.

LUMBRICUS TERRESTRIS - EARTHWORM.

Median longitudinal section of the anterior part of the body.

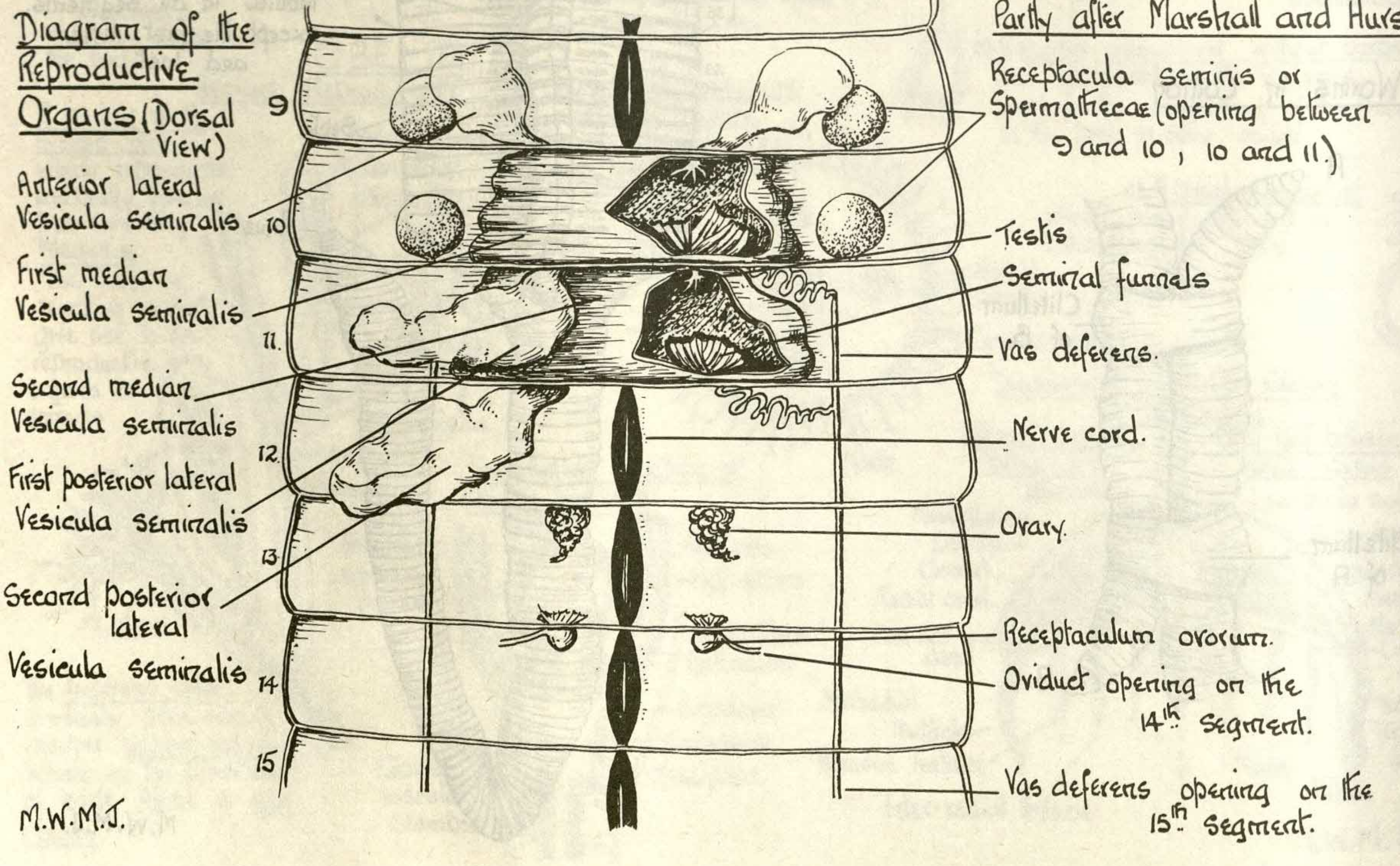


Principal Blood Vessels.



Partly after Marshall and Hurst.

Diagram of the Reproductive Organs (Dorsal View)



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LUMBRICUS TERRESTRIS - EARTHWORM.

Diagrammatic transverse section through the intestinal region of the body.

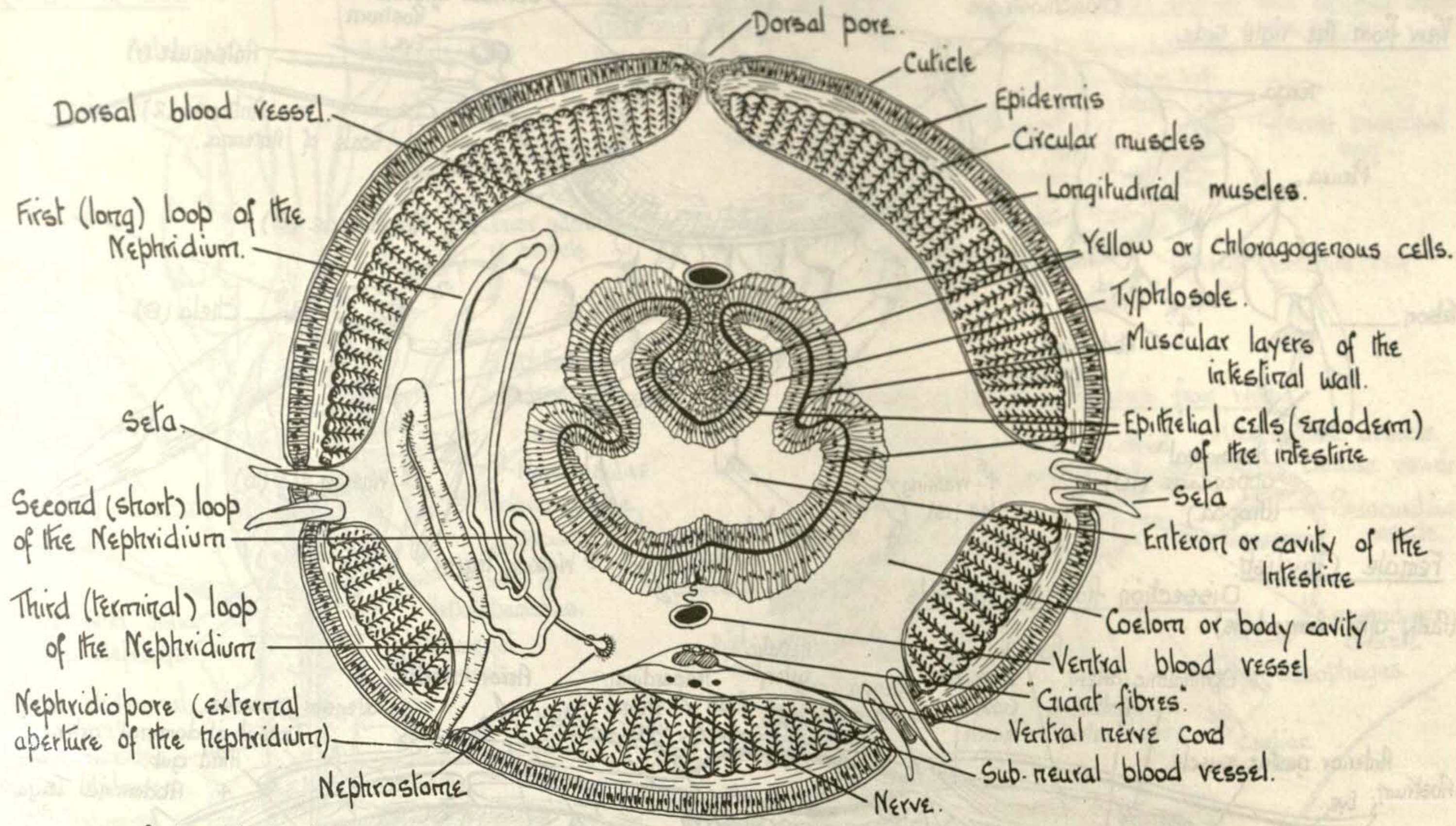


Diagram of the Nephridium. (Teased out)

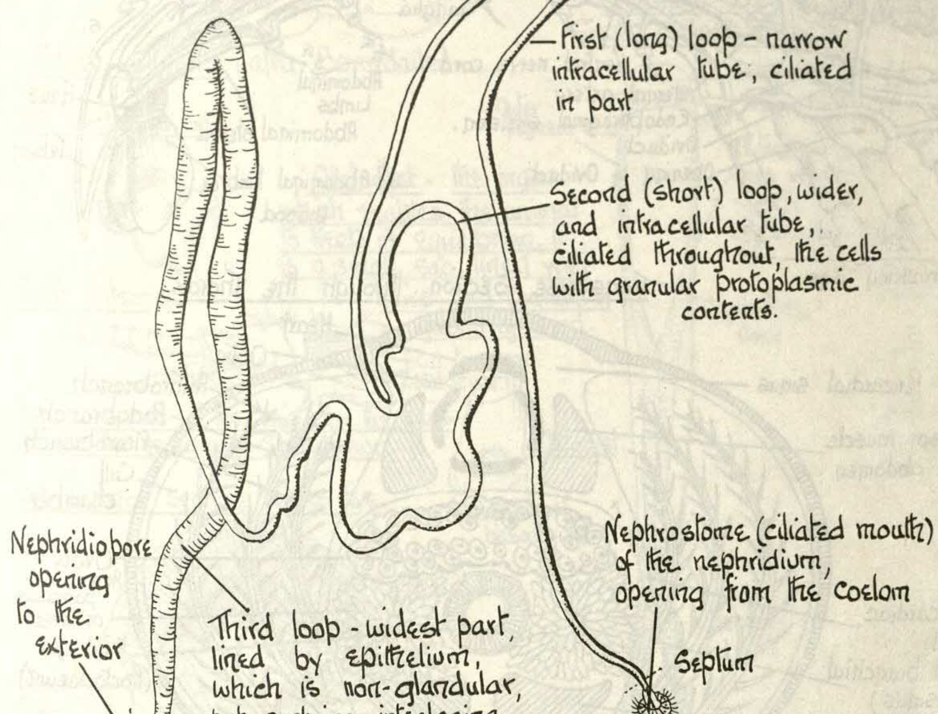
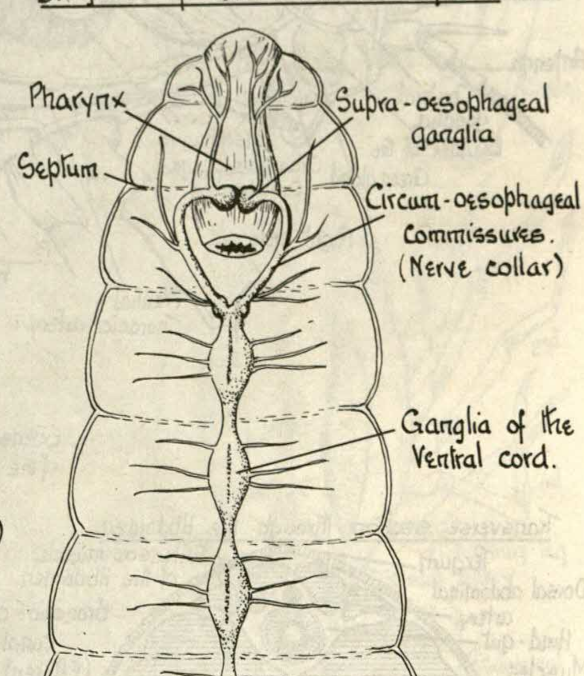


Diagram of the Nervous System



Seta

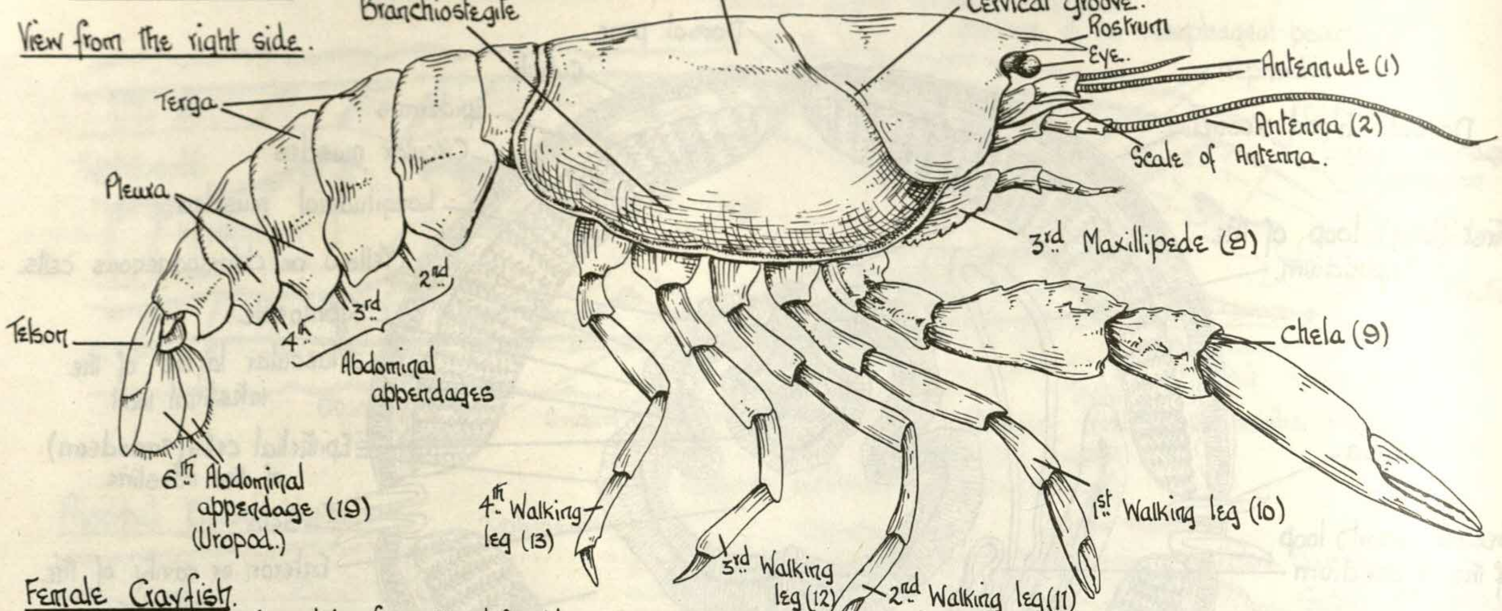
Removed from the seta sac.

M.W.M.T.

ASTACUS - CRAYFISH

External Features.

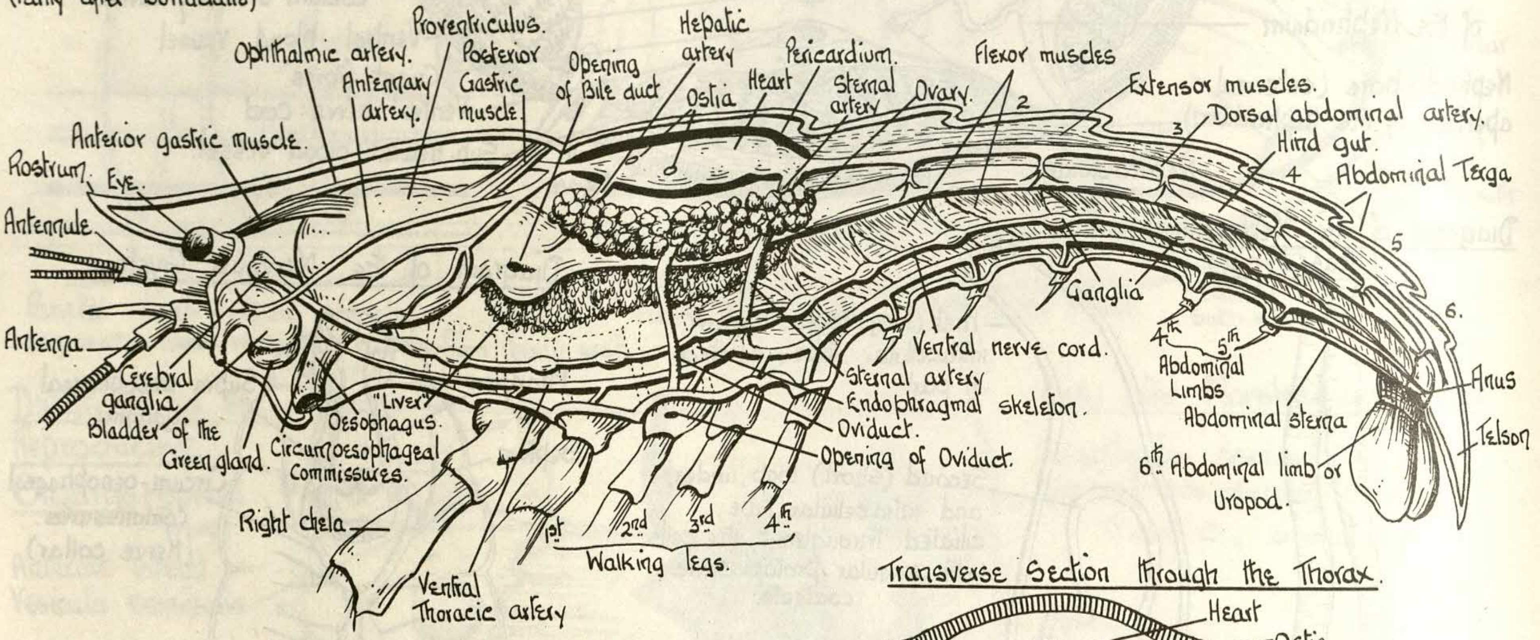
View from the right side.



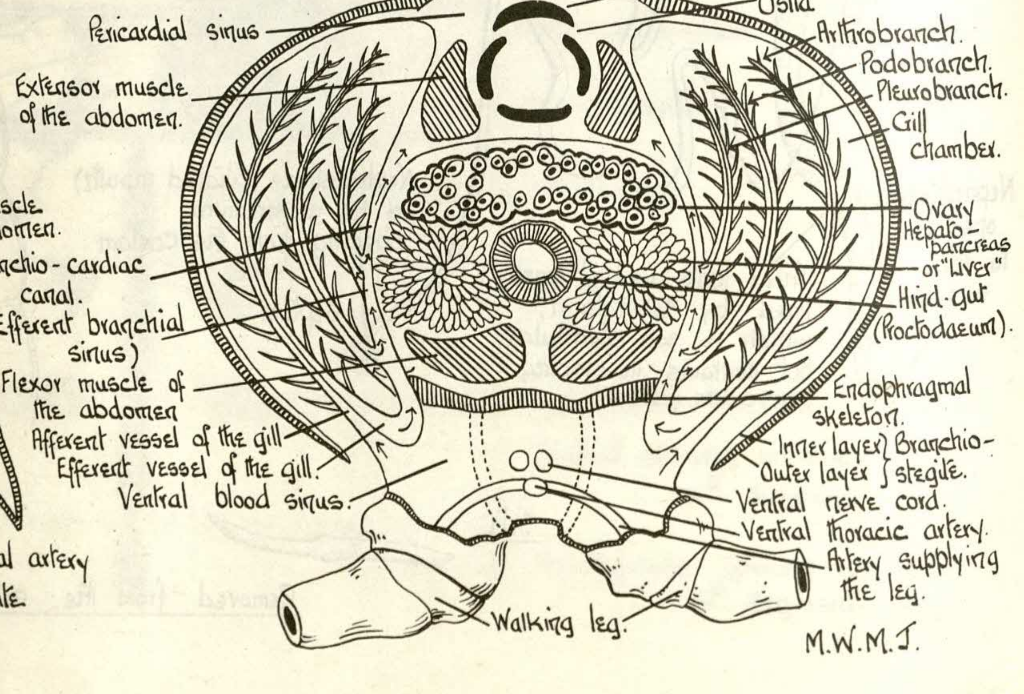
Female Crayfish.

Dissection from the left side.

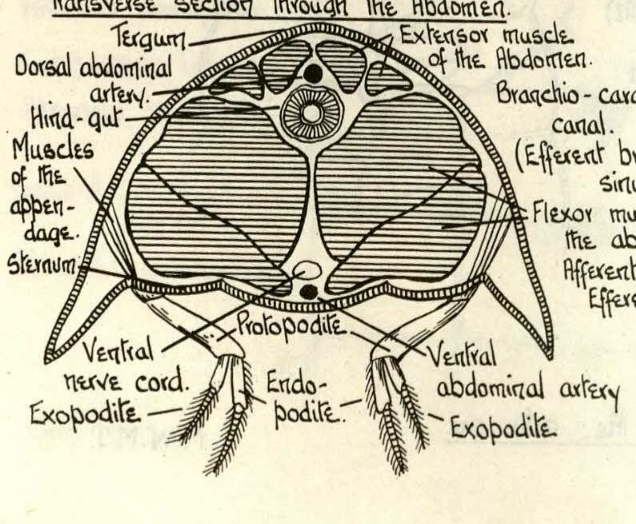
(Partly after Borradaile)



Transverse Section through the Thorax.



Transverse section through the Abdomen.



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ASTACUS — CRAYFISH

Male Crayfish. Organs in situ.

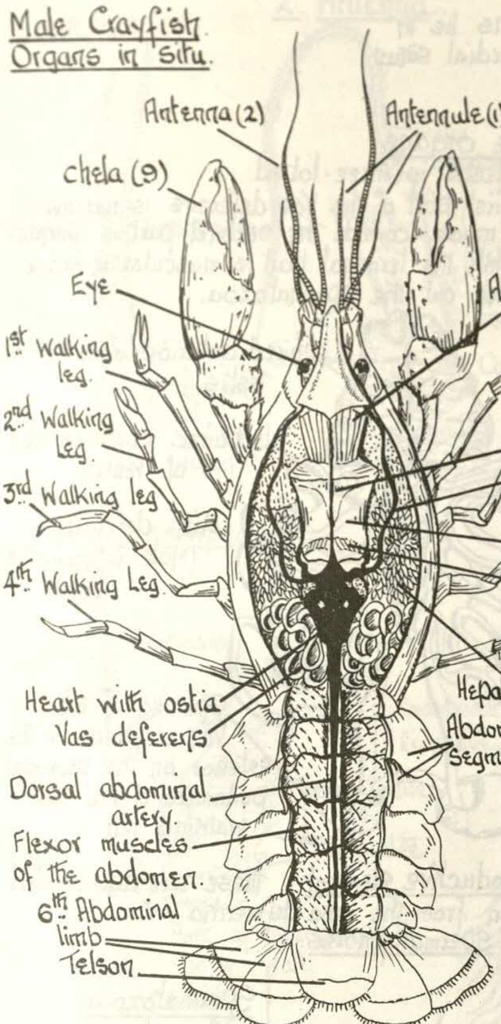
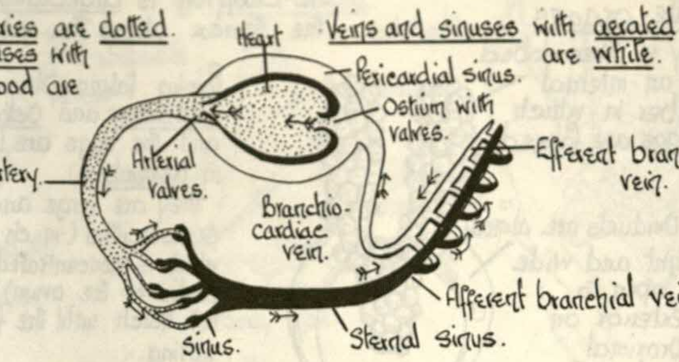


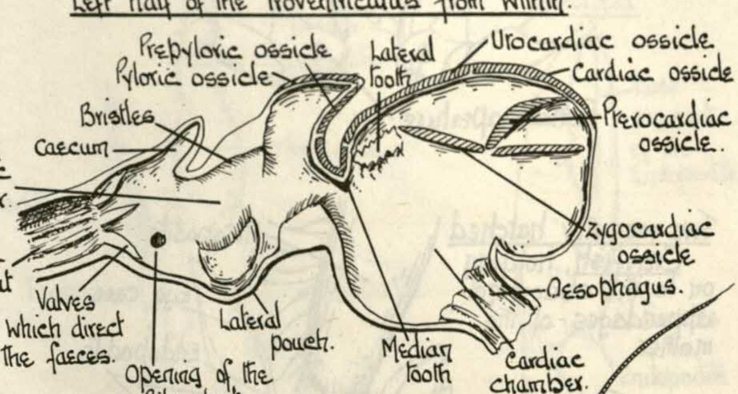
Diagram of the Circulation (after Parker and Haswell)

Heart and arteries are dotted. Veins and sinuses with non-aerated blood are black.

Veins and sinuses with aerated blood are white.



Left half of the Proventriculus from within.



Sense Organs (after Borradaile)

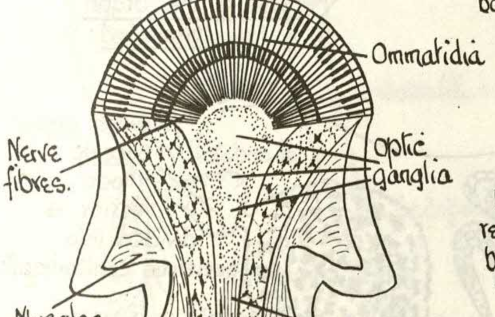
Left compound eye.

Statocyst - the organ which enables the animal to keep its equilibrium. It is a small sac, lined with hairs, and containing grains of sand.

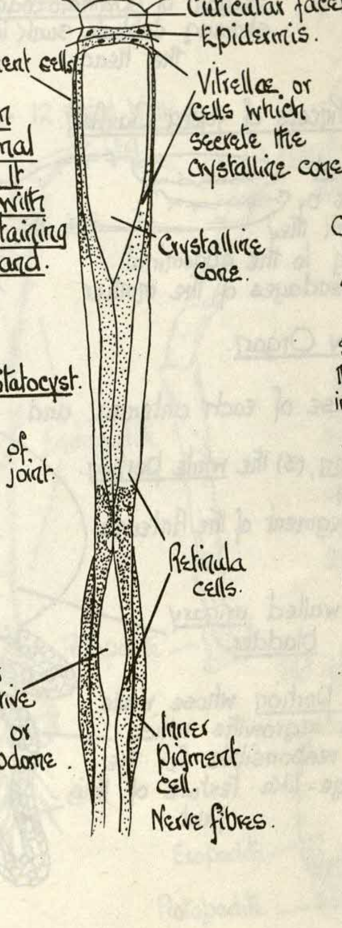
Right Antennule.

The movement of the grains on the hairs affords the necessary stimulation.

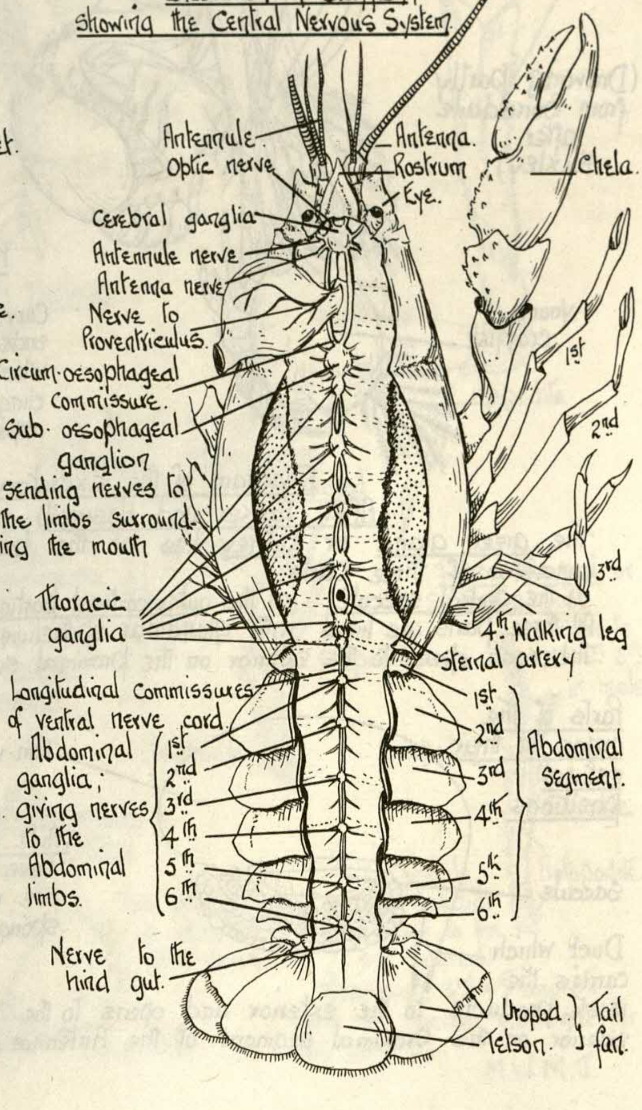
Longitudinal section of the Eye.



Compound Eye. Single Ommatidium.



Dissection of Crayfish, showing the Central Nervous System.

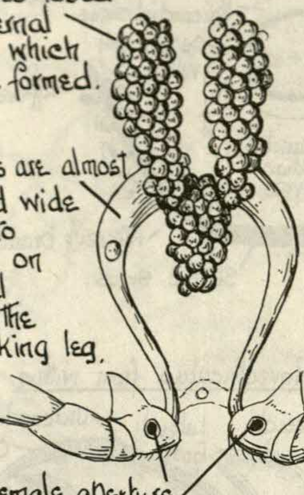


M.W.M.J.

ASTACUS - CRAYFISH. REPRODUCTIVE AND EXCRETORY ORGANS.

The Crayfish is dioecious. The generative organs lie in the thorax above the gut, and below the pericardial sinus.

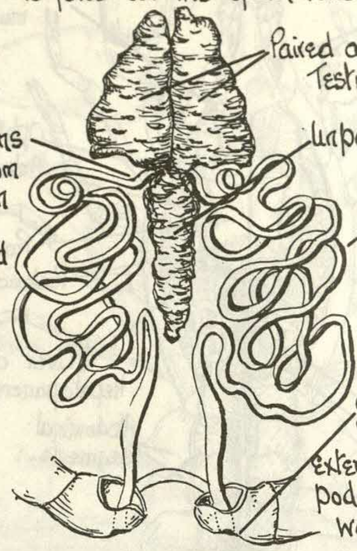
Female organs.



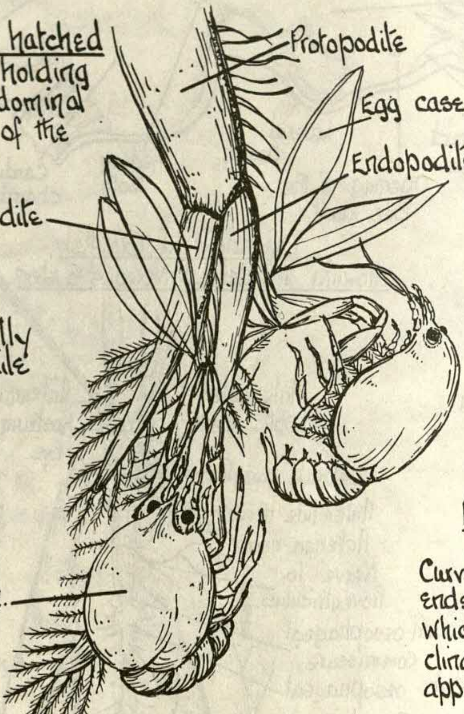
Pairing takes place in September and October, and the eggs are laid in November. They are large and centrolecithal (much yolk which is concentrated in the centre of the ovum) and do not hatch until the following spring.

Male organs.

The testis is three-lobed. The first part of the Vas deferens is narrow and much coiled. The second part is glandular, while the terminal part is muscular in order to force out the spermatozoa.



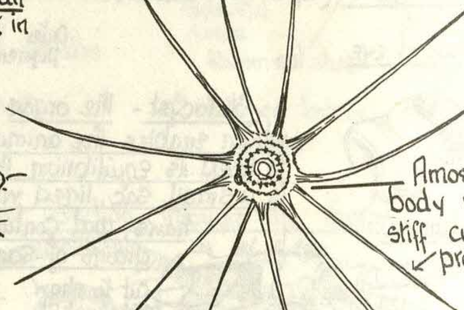
Two recently hatched Crayfish, holding on to the abdominal appendages of the mother.



(Drawing partly from Borradaile after Huxley.)

Spermatozoan - Male reproductive element these are aggregated by a secretion from the Vasa deferentia into spermatophores.

Section of spermatozoan showing capsule sunk in the head.



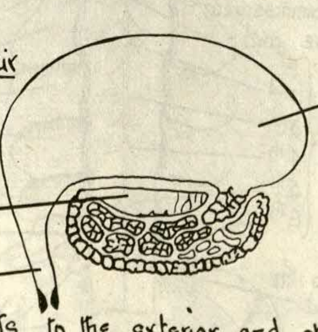
Pincers of young Crayfish.

Diagram of the Excretory Organ.

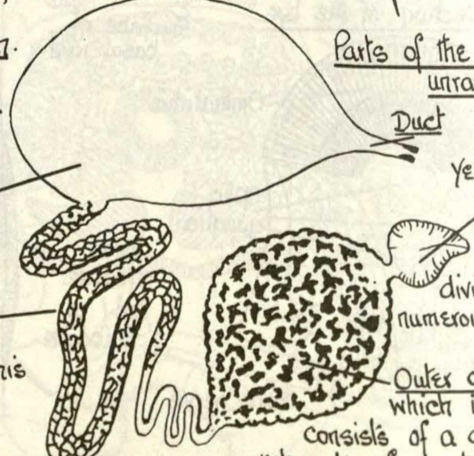
(After Parker and Haswell)

The green gland or Kidney lies at the base of each antenna, and consists of three parts:-
(1) the central saccule, (2) the outer cortical portion, (3) the white portion.
All three parts are lined with glandular epithelium.
The organ opens to the exterior on the proximal segment of the Antenna.

Parts of the organ in their natural positions.

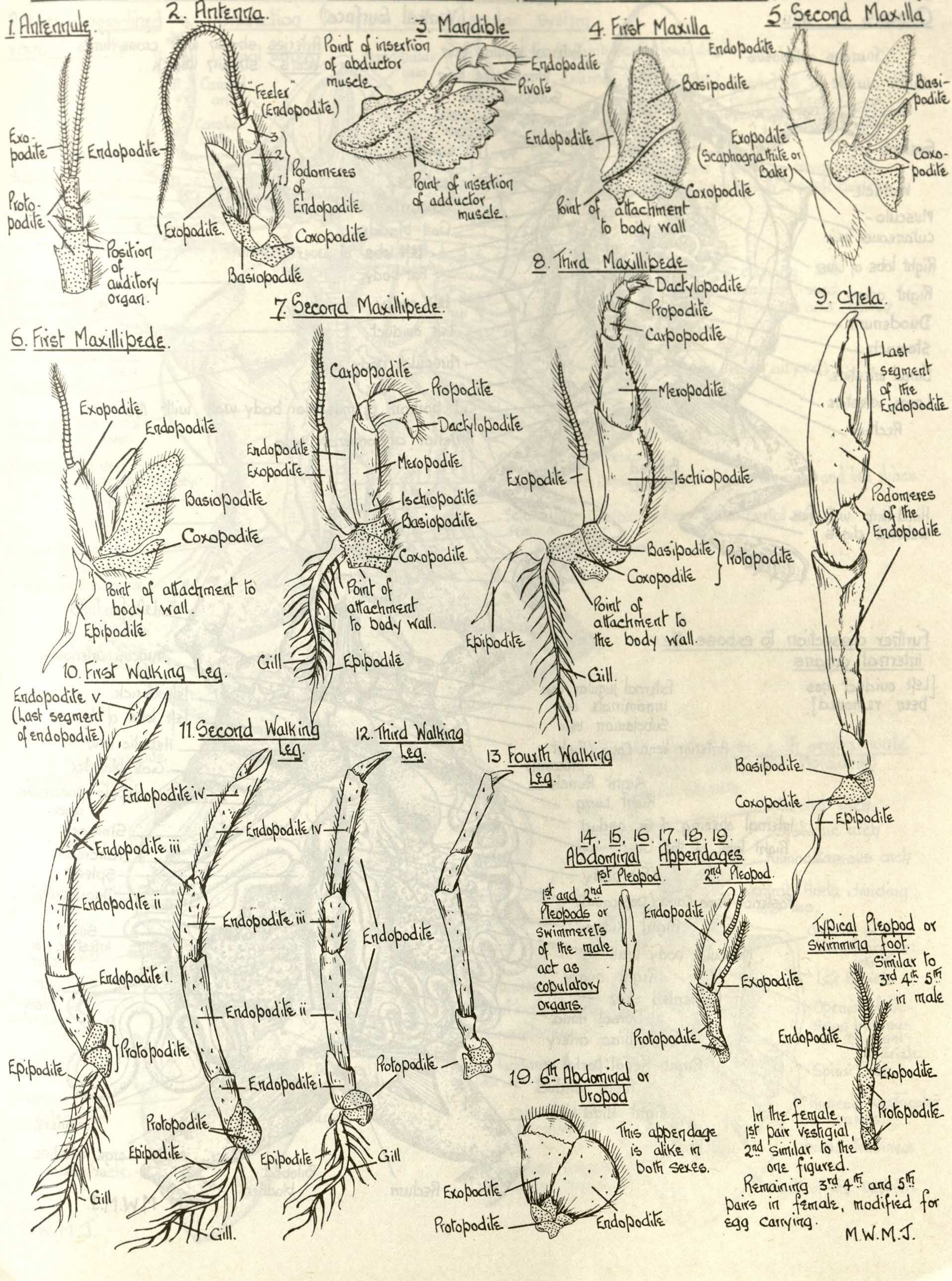


Parts of the organ unravelled.



M.W.M.J

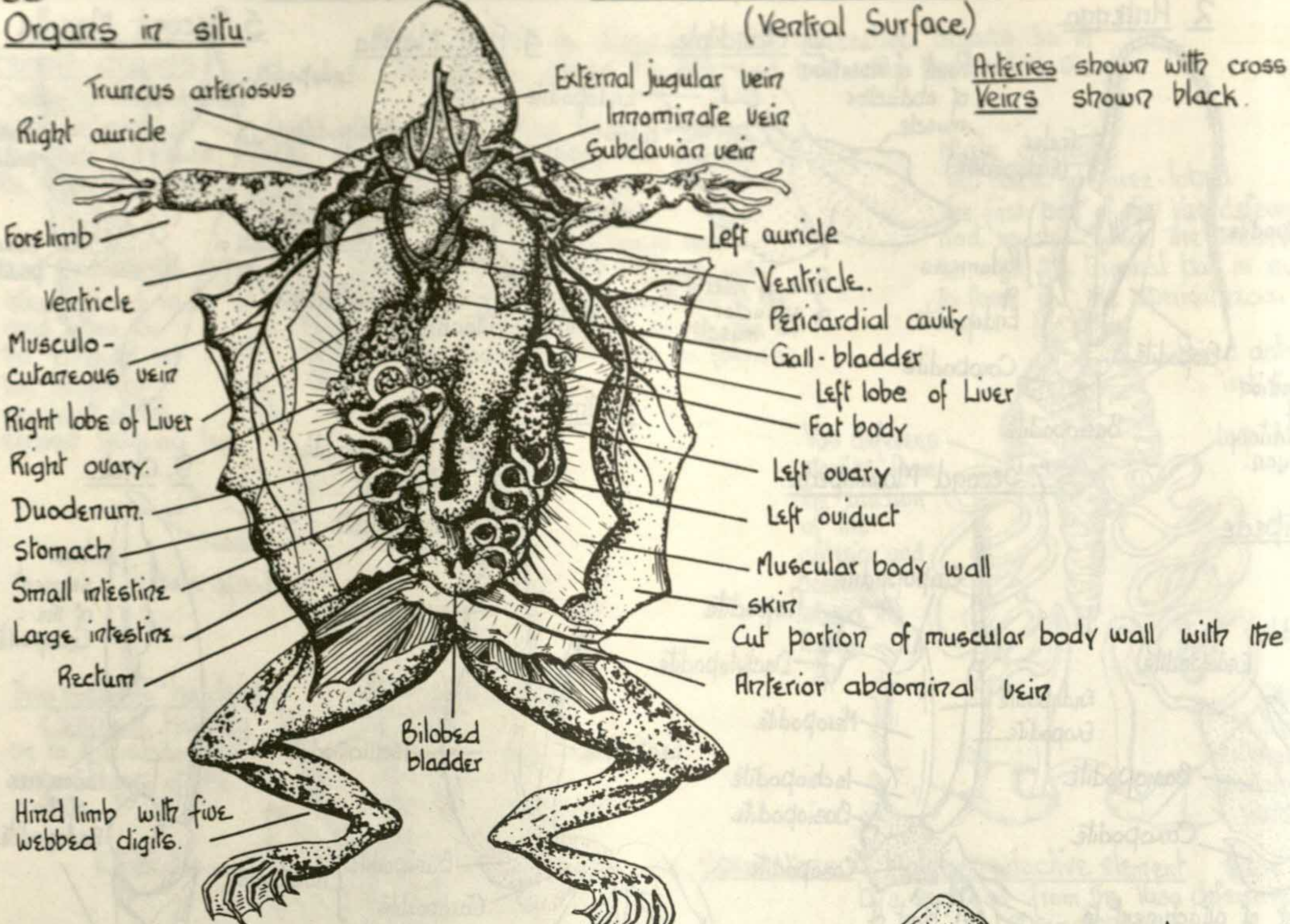
ASTACUS - CRAYFISH. APPENDAGES (Protopodite dotted throughout)



DISSECTION OF RANA TEMPORARIA
(Ventral Surface)

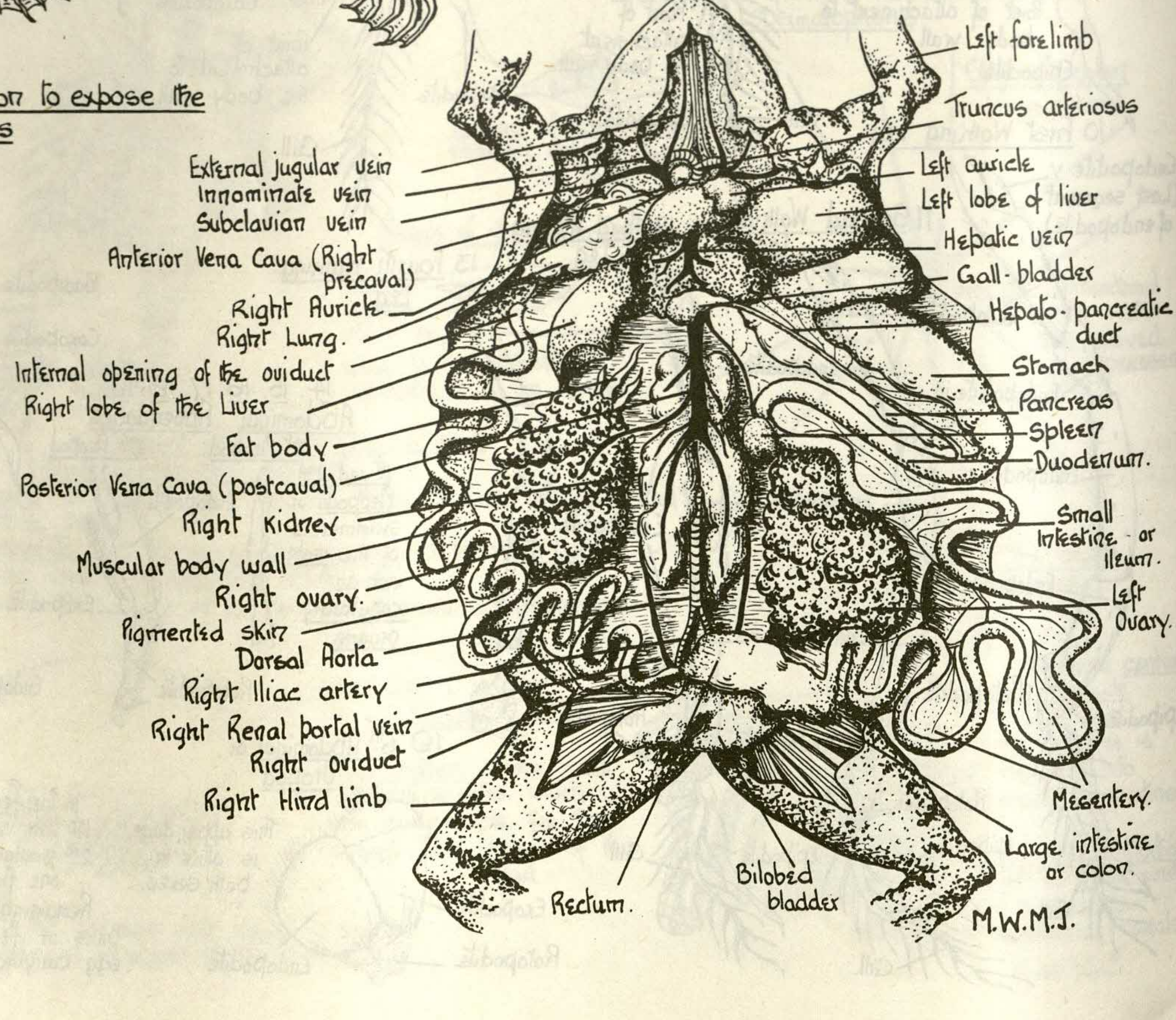
Organs in situ.

Arteries shown with cross lines
Veins shown black.



Further dissection to expose the internal organs

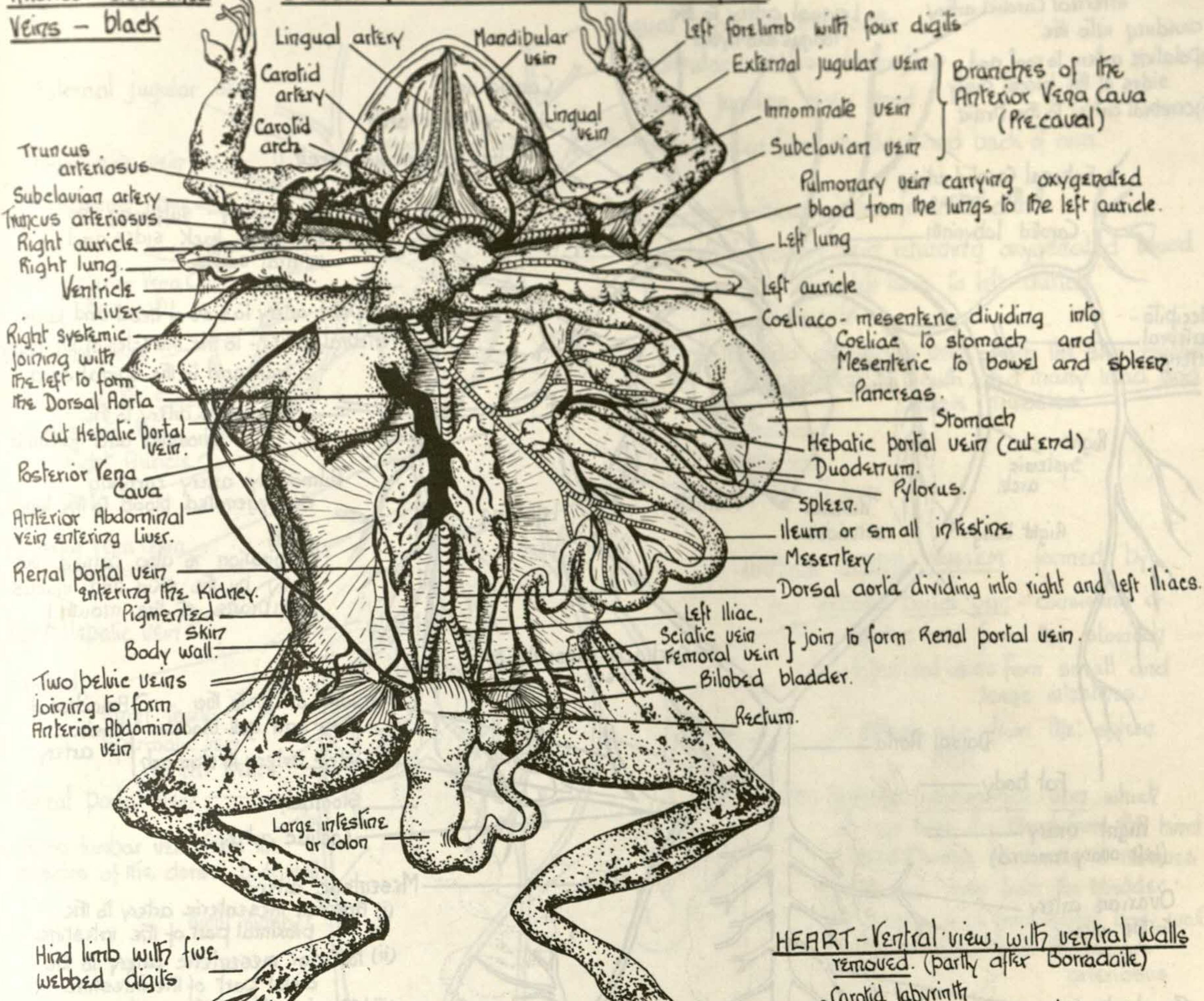
[Left oviduct has been removed]



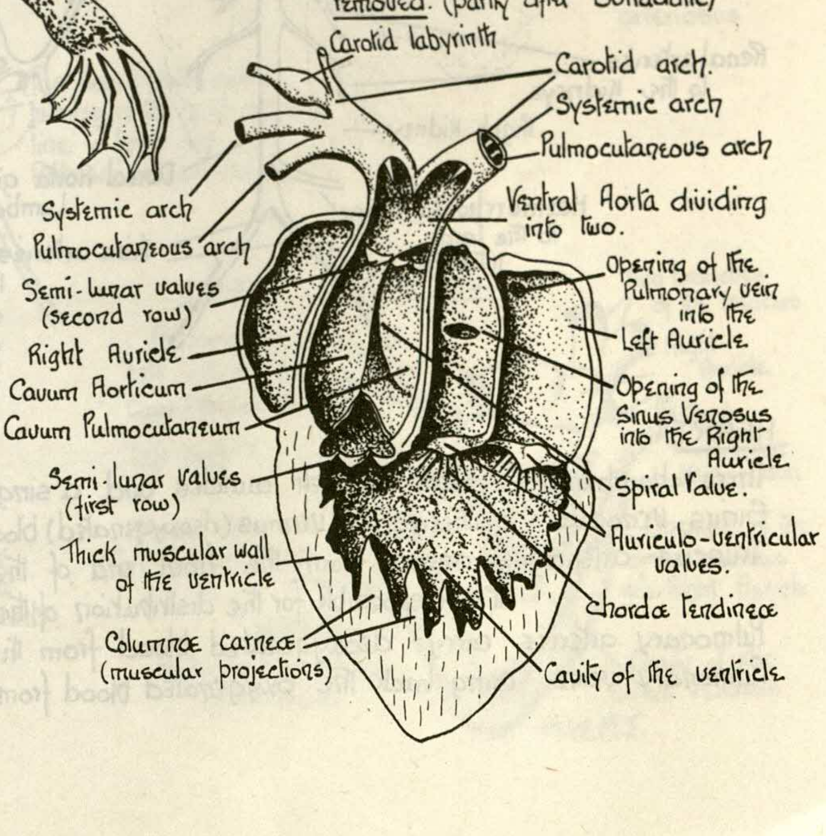
M.W.M.J.

Arteries—cross-lined
Veins - black

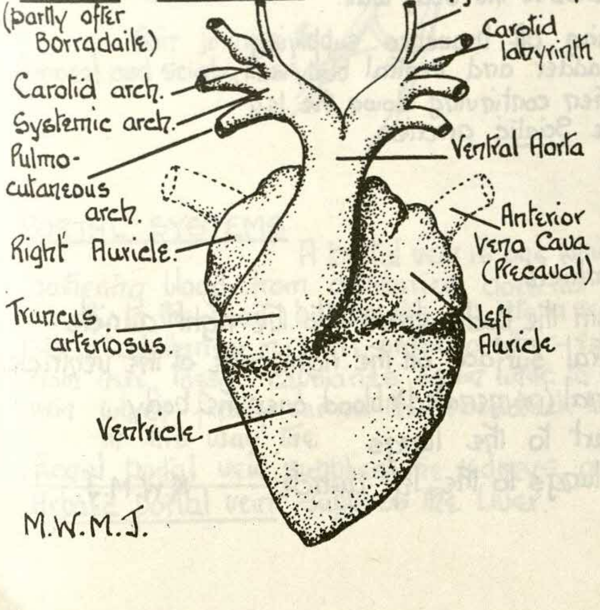
Dissection to show the Vascular system



HEART—Ventral view, with ventral walls removed. (partly after Borradaile)

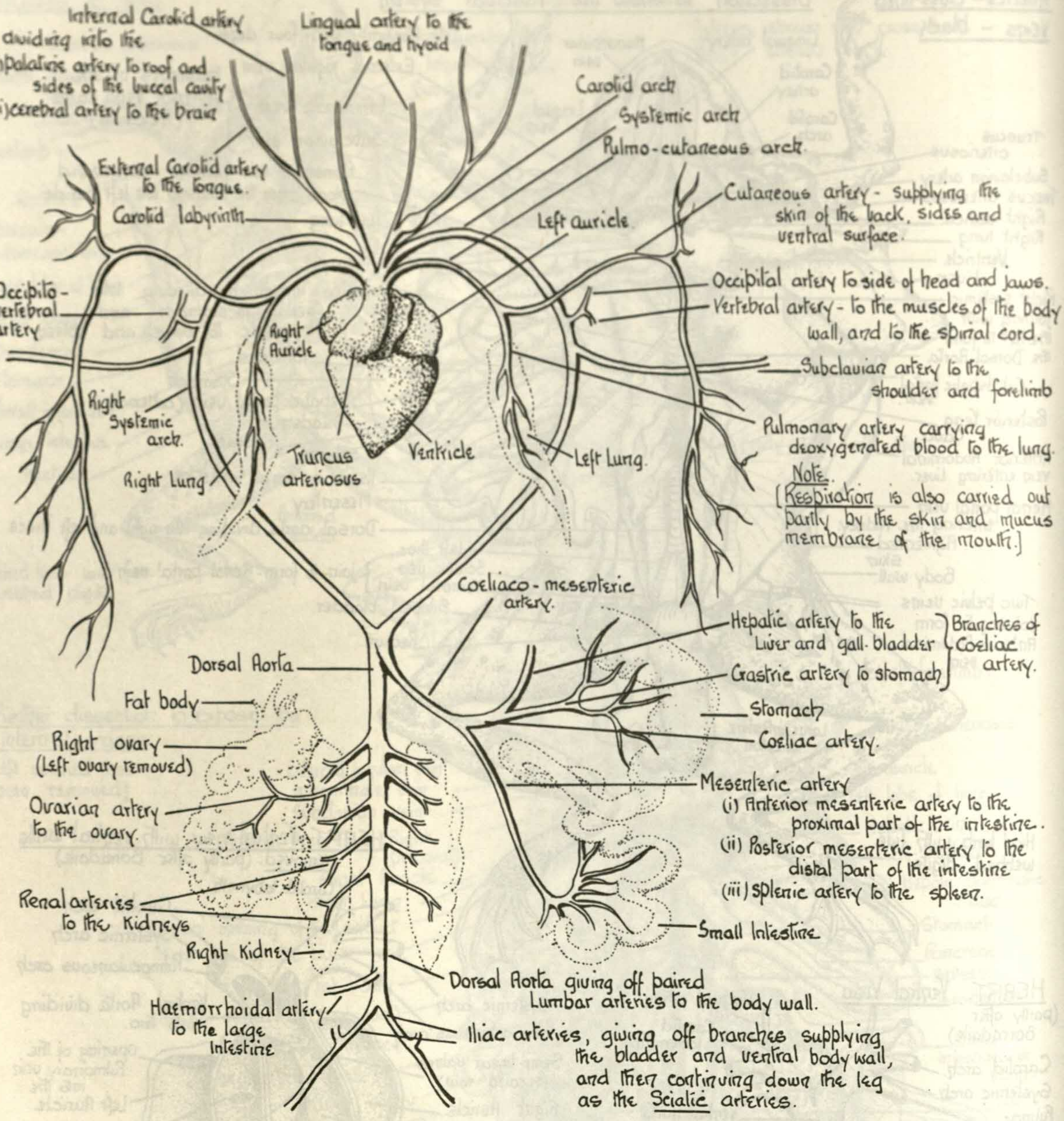


HEART. Ventral View
(partly after Borradaile)



M.W.M.J.

40. RANA TEMPORARIA - ARTERIAL SYSTEM. Ventral View.



HEART.

Three-chambered — Right and left auricles and a single ventricle.

Sinus venosus gathering the venous (deoxygenated) blood from the body opens into the right auricle

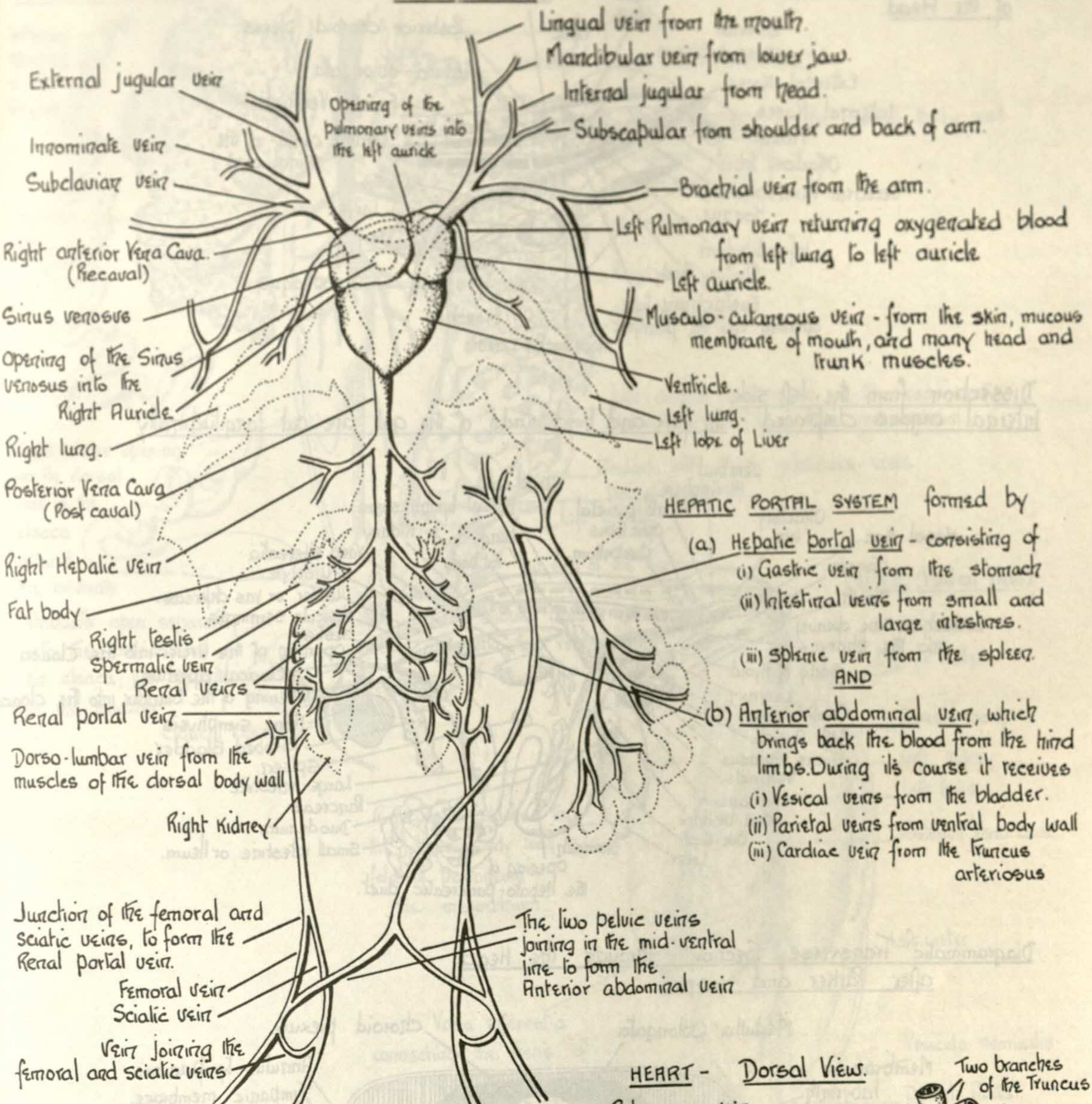
Truncus arteriosus arises from the front end of the ventral surface on the right side of the ventricle. It is responsible for the distribution of the arterial (oxygenated) blood over the body.

Pulmonary arteries carry deoxygenated blood from the heart to the lungs

Pulmonary veins bring back the oxygenated blood from the lungs to the left auricle

M.W.M.J.

Ventral View.



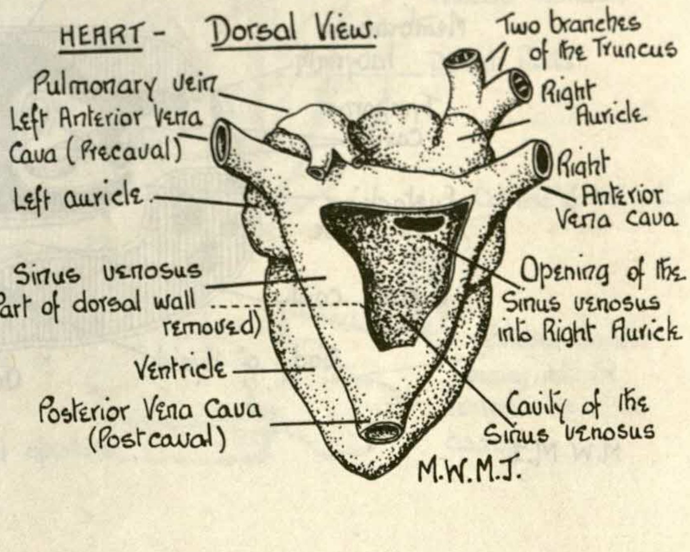
HEPATIC PORTAL SYSTEM formed by

(a.) Hepatic portal vein - consisting of
(i) Gastric vein from the stomach
(ii) Intestinal veins from small and large intestines.
(iii) Splenic vein from the spleen.

AND

(b) Anterior abdominal vein, which brings back the blood from the hind limbs. During its course it receives
(i) Vesical veins from the bladder.
(ii) Parietal veins from ventral body wall
(iii) Cardiac vein from the truncus arteriosus

HEART - Dorsal View.

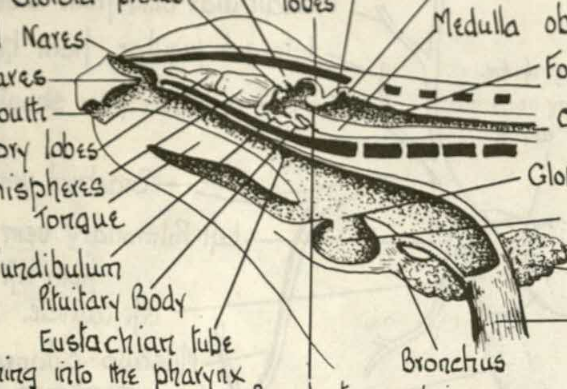


PORTAL SYSTEMS

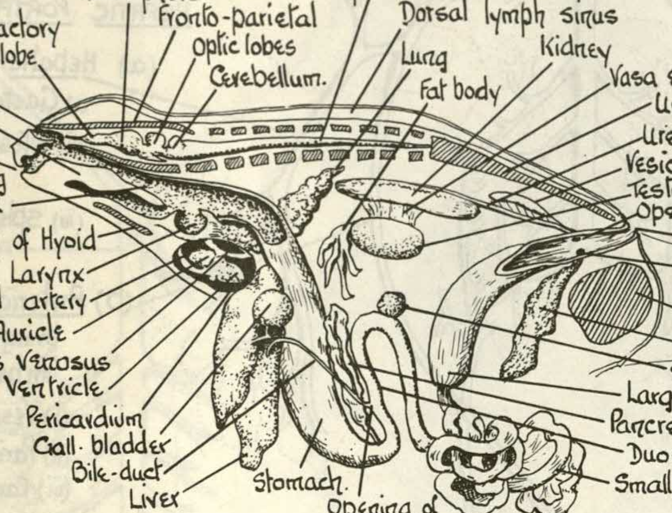
A portal vein is one which, gathering blood from capillaries, does not go directly to the heart, but breaks up into a second set of capillaries in some organ or other - e.g. Liver. From here, these capillaries again unite to form a vein which finally carries the blood back to the heart. In this way the Renal portal vein supplies the kidneys, and the Hepatic portal vein supplies the Liver.

RANA TEMPORARIA. VARIOUS SECTIONS OF THE BODY.

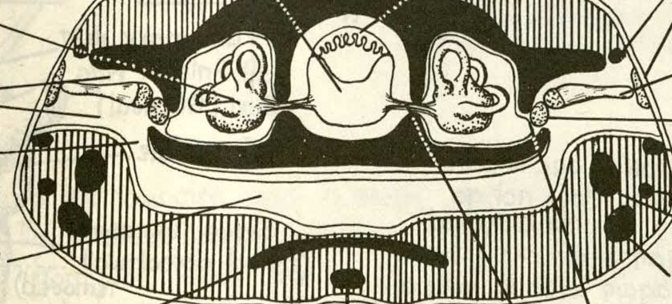
Median Longitudinal Section of the Head.



Dissection from the left side Internal organs displaced - The fore and hind ends of the gut are cut longitudinally

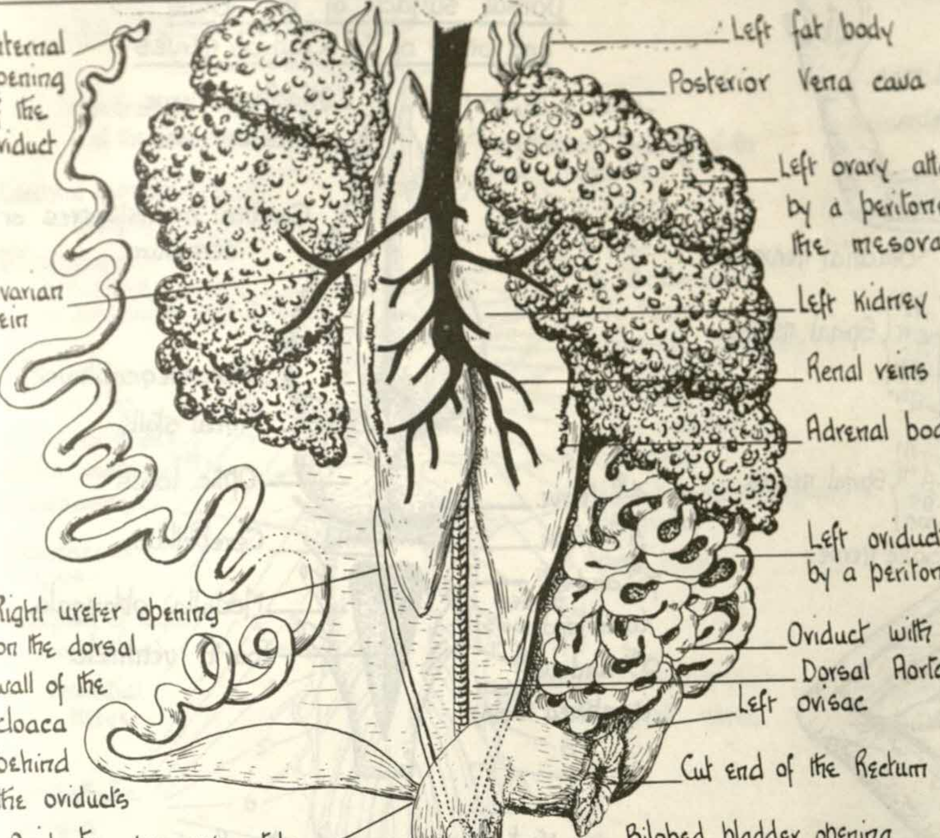


Diagrammatic Transverse Section through the Head. after Parker and Haswell.

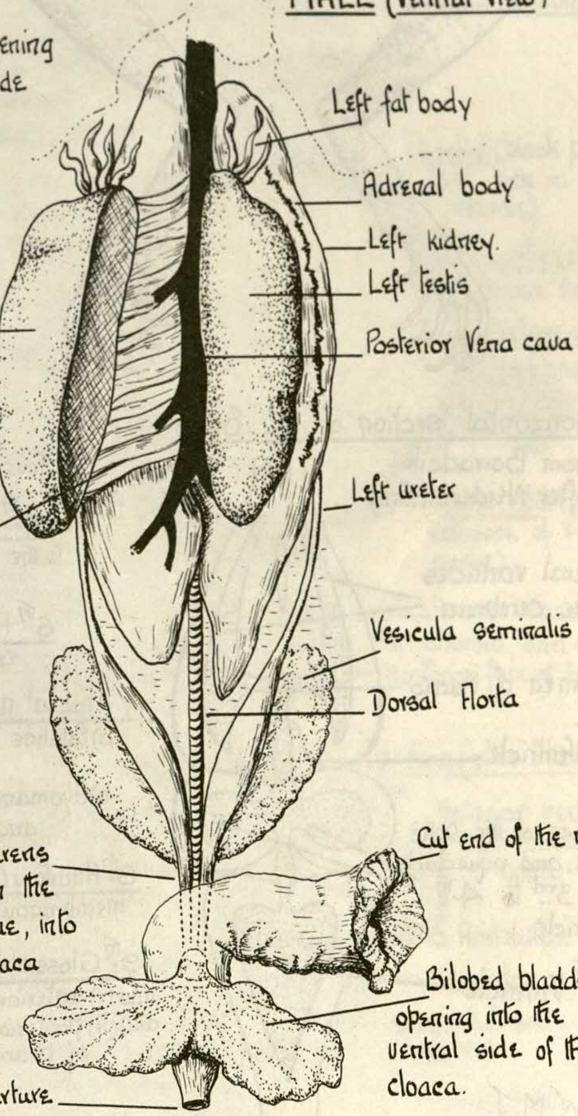


M.W.M.T.

FEMALE (Ventral View)



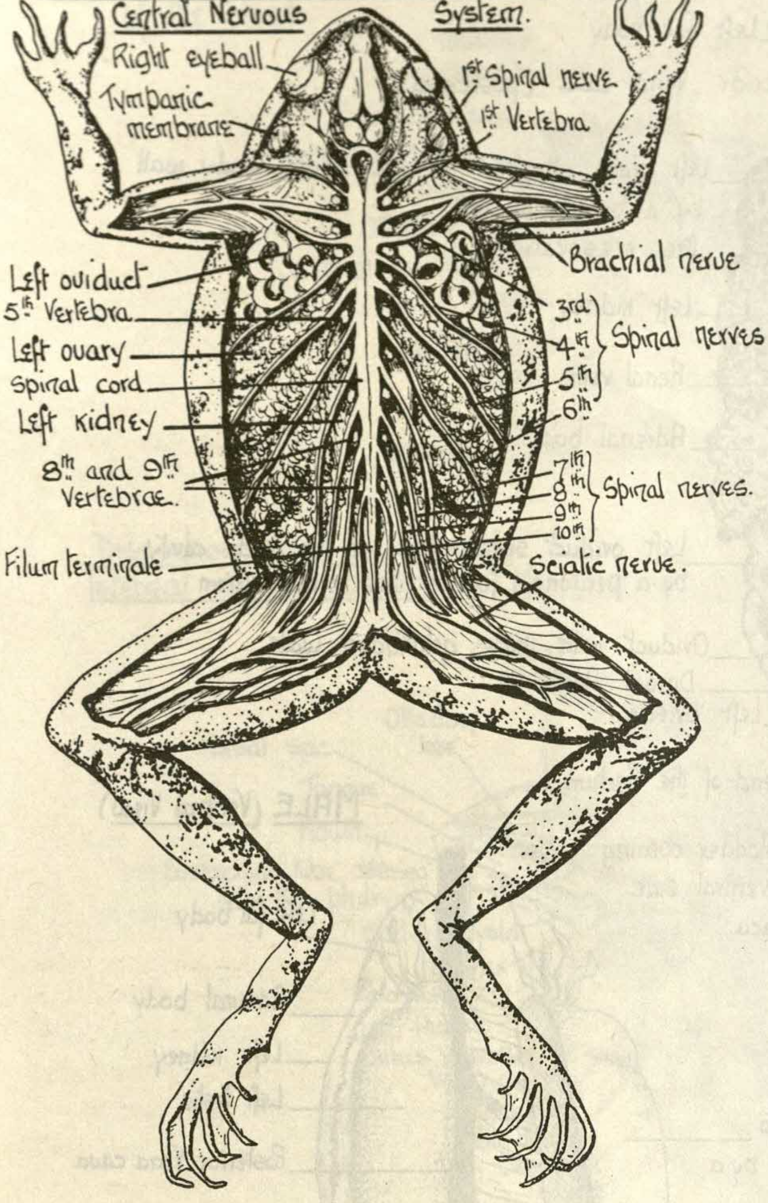
MALE (Ventral View)



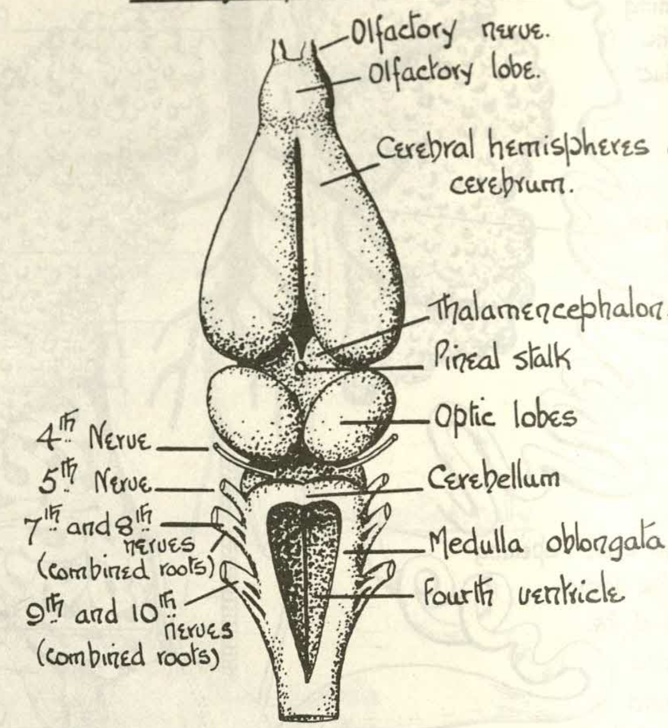
M.W.M.J.

RANA TEMPORARIA - CENTRAL NERVOUS SYSTEM.

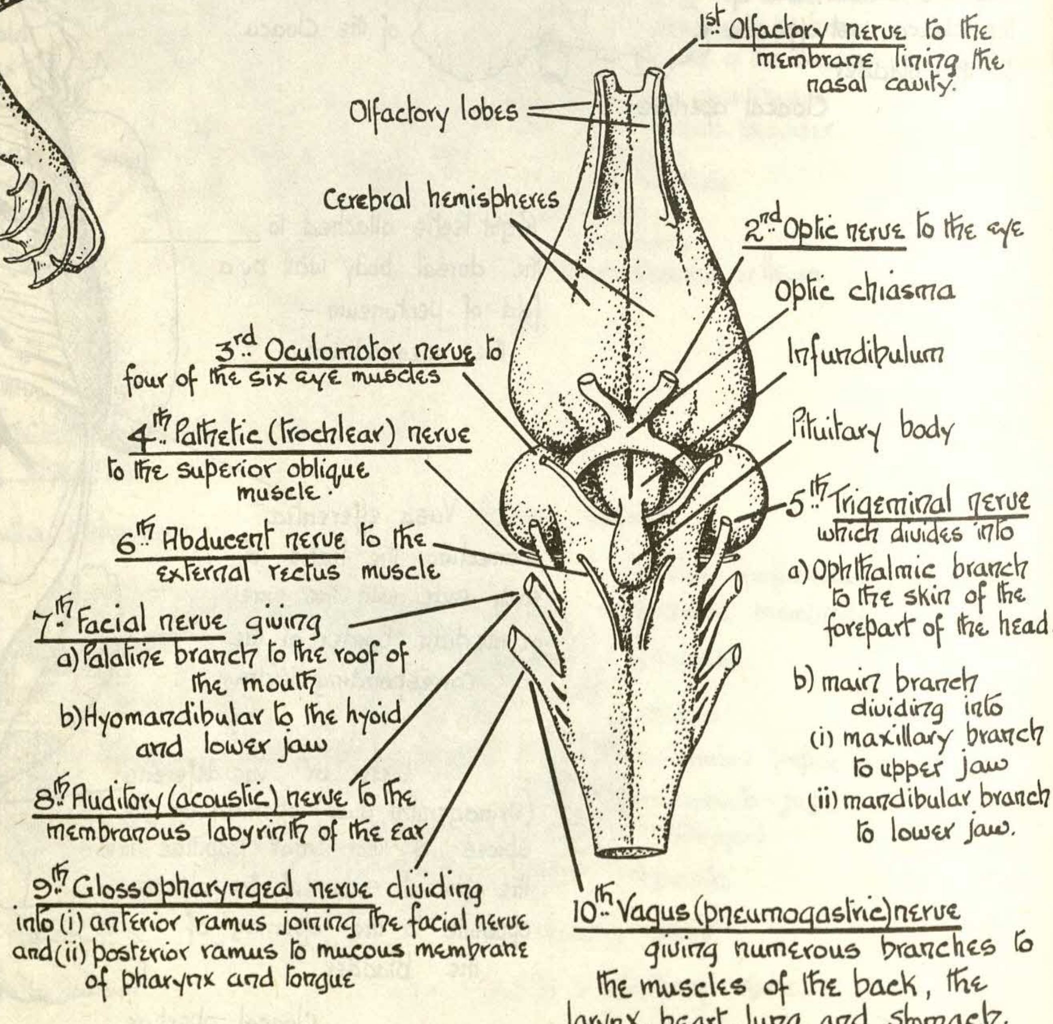
Dissection from the dorsal surface to expose the Central Nervous System.



Dorsal surface of the Brain and origin of the Cranial nerves.

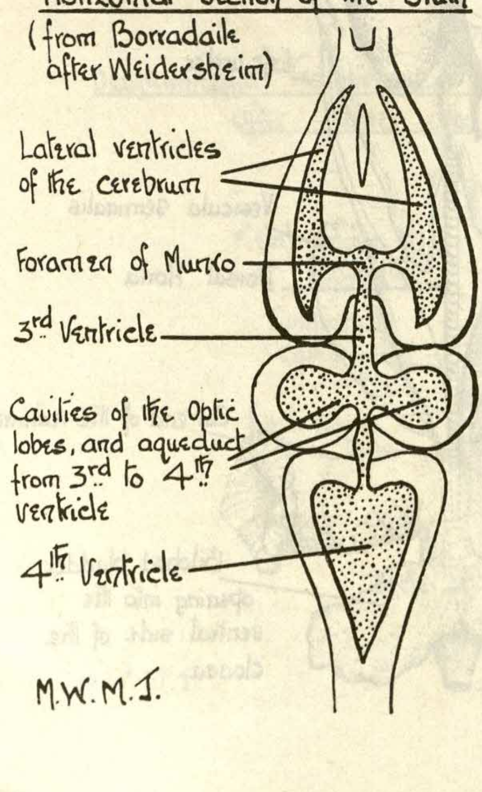


Ventral surface of the Brain



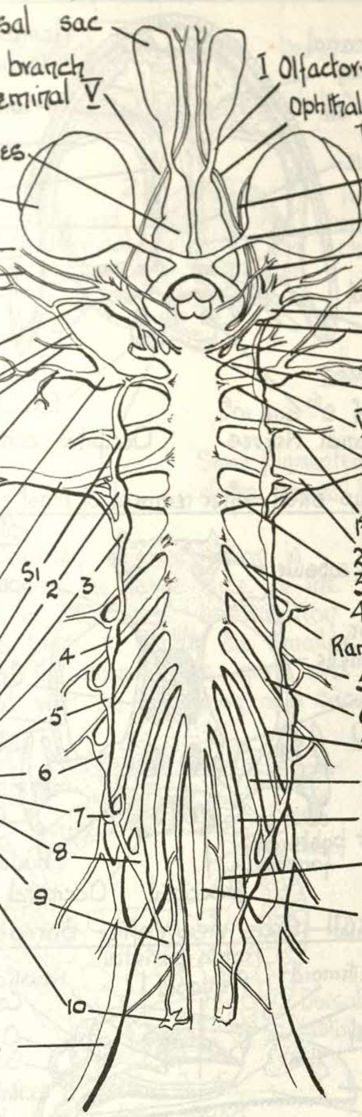
Horizontal section of the Brain

(from Borradaile after Weidersheim)



M.W.M.J.

Nervous System - Ventral View.
(from Marshall, after Ecker)



Origin of the Spinal Nerves in Frog.

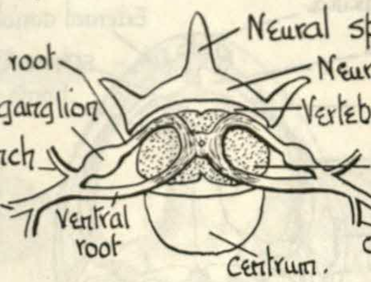
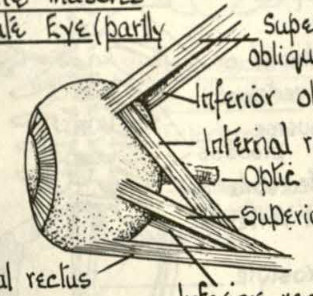


Diagram showing the attachment of the muscles in the Vertebrate Eye (partly after Parker and Haswell.)



A diagrammatic section through the Vertebrate Eye.

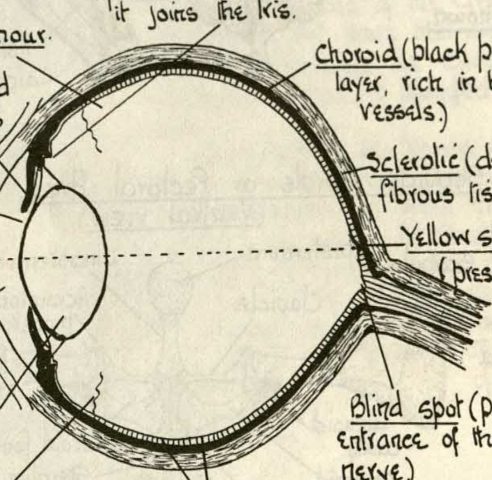
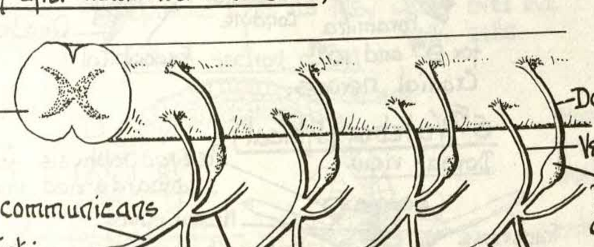
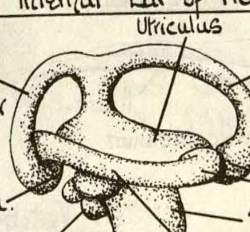


Diagram to show the relationship of the Sympathetic Nerve cord to the Spinal Nerves
(partly after Hentschel and Cook)



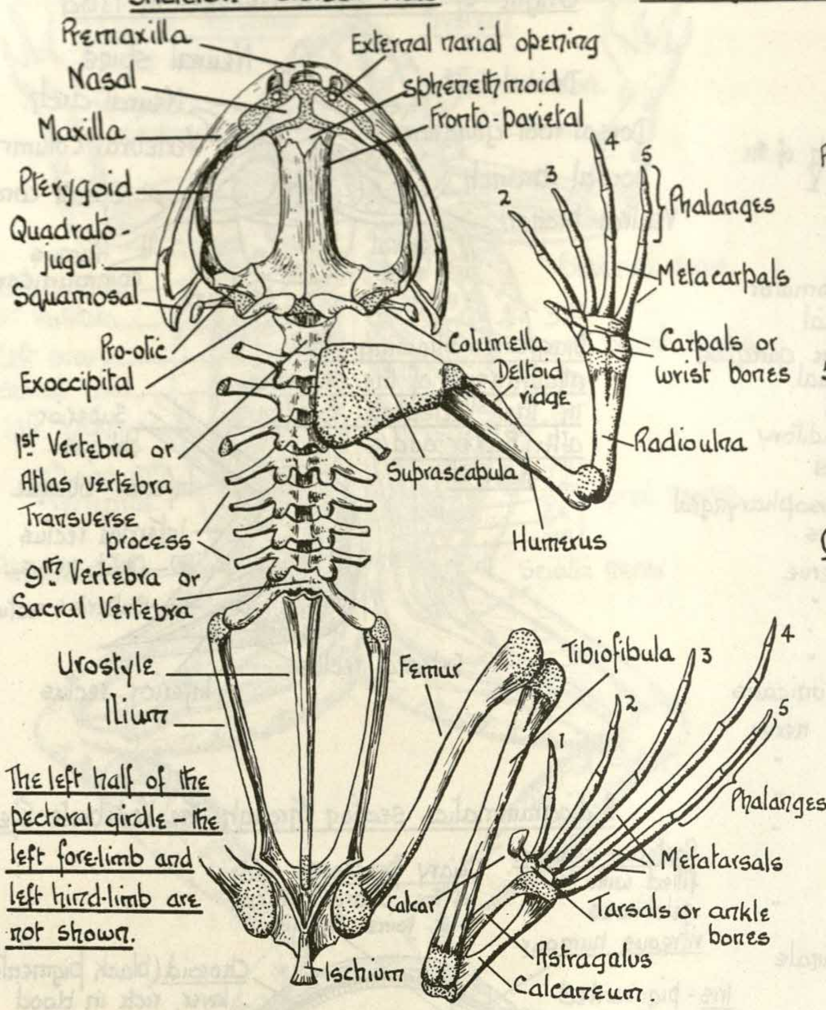
Right Internal Ear of Frog (after Marshall.)



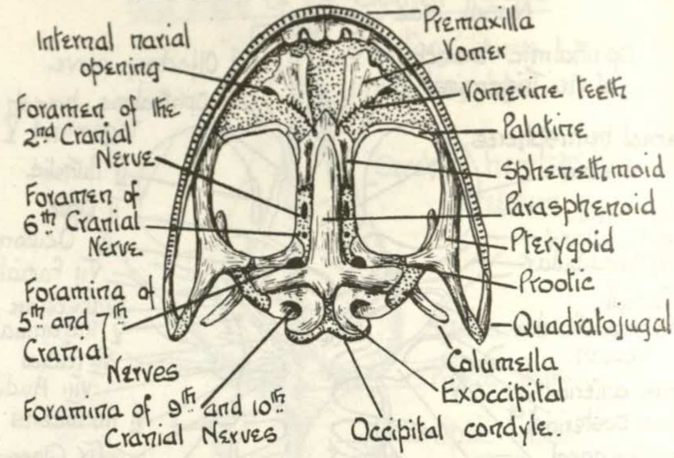
M.W.M.J.

Cartilaginous parts dotted.

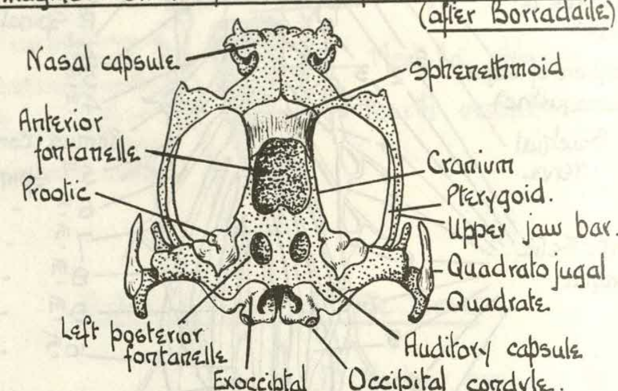
Skeleton - dorsal view.



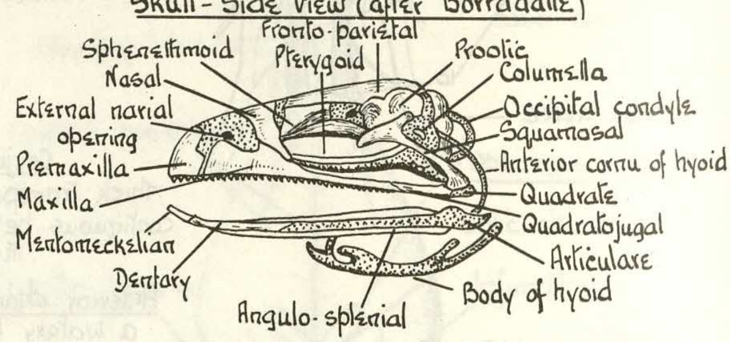
Skull - Ventral View (after Borradaile)



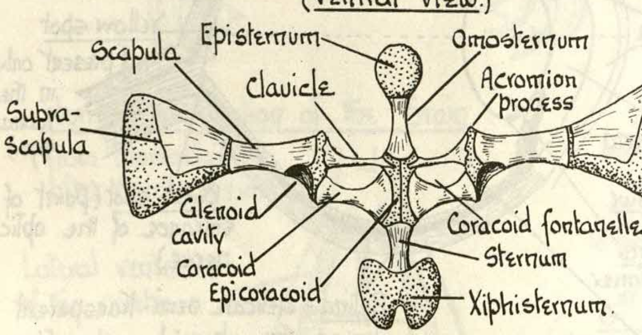
Cartilaginous skull - after removal of most of the bones (after Borradaile)



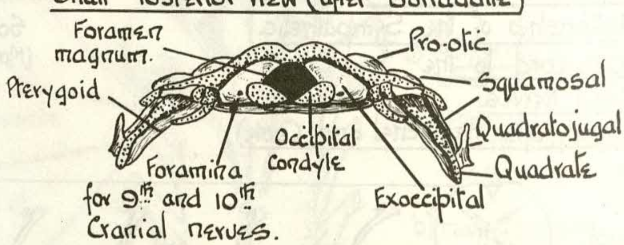
Skull - Side view (after Borradaile)



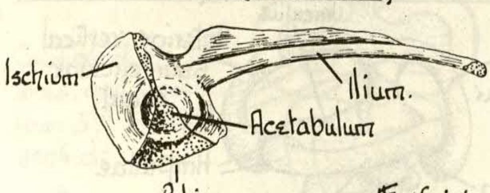
Shoulder Girdle or Pectoral Arch. (Ventral view.)



Skull - Posterior View (after Borradaile)



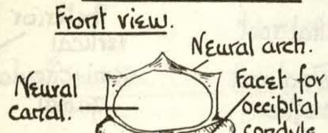
Hip Girdle or Pelvic Arch (Side view.)



Vertebrae.

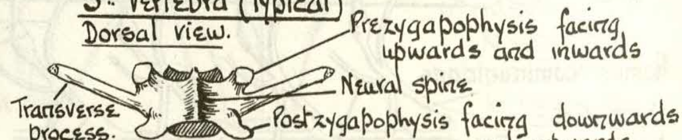
1st Vertebra or Atlas

Front view.



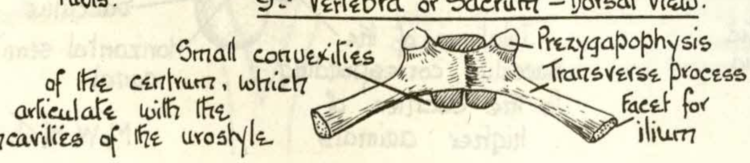
5th Vertebra (Typical)

Dorsal view.

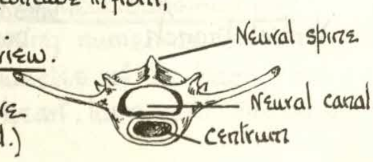


Centrum procoelous (concave in front, convex behind)

9th Vertebra or Sacrum - Dorsal view.



8th Vertebra - Front view.



Centrum amphicoelous - (concave in front, concave behind.)

M.W.M.J.

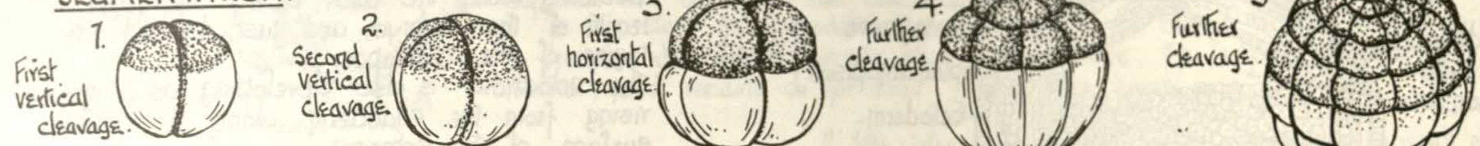
RANA TEMPORARIA - FROG - LIFE HISTORY.

The eggs of the ordinary English frog - Rana temporaria are laid about March. Each egg is surrounded by the delicate vitelline membrane, on the outside of which is deposited the gelatinous secretion, which after fertilisation swells up considerably, forming the familiar frog spawn.

The egg is telolecithal, the yolk being aggregated at the lower white vegetable pole.

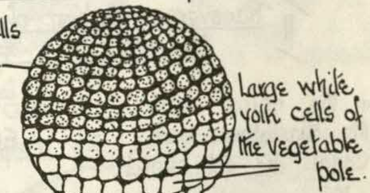
The segmentation is holoblastic (complete), but unequal.

SEGMENTATION.

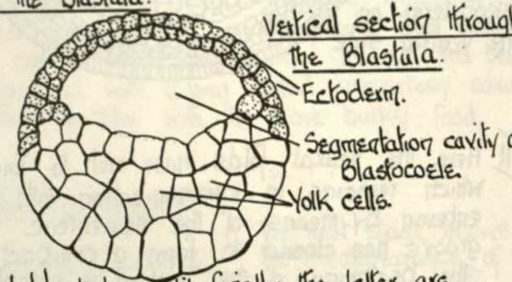


Close of segmentation and formation of the Blastula.

Further cleavage to form Blastula.



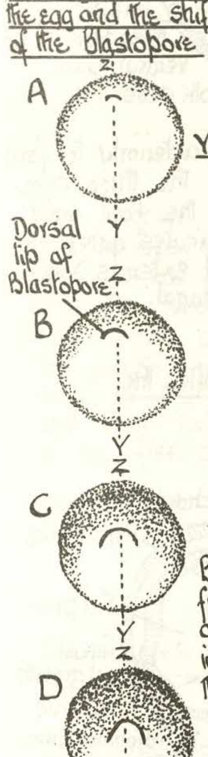
Vertical section through the Blastula.



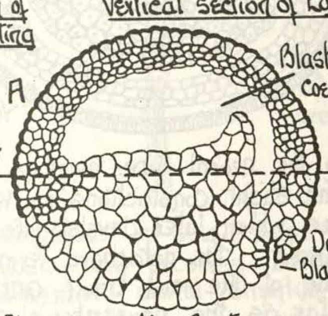
GASTRULATION.

Gastrulation by emboly or invagination is impossible because of the large size of the yolk cells so that in this case, gastrulation by epiboly takes place in which the smaller pigmented cells of the animal pole grow over the larger white cells of the vegetable pole, until finally the latter are completely covered with the exception of a circular patch - the blastopore, which is plugged by a mass of yolk cells.

Under surface of the egg showing the rotation of the egg and the shifting of the Blastopore



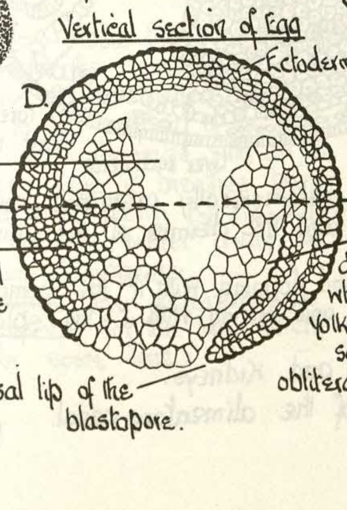
Vertical section of Egg.



Above in section A, the blastula is little altered since the epiboly of the ectoderm cells has only just begun. The small pit is the commencement of the Blastoporic slit.

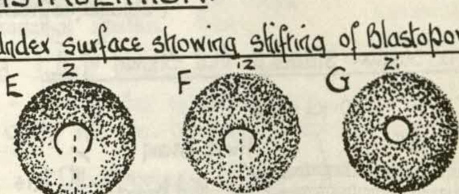
Below, section D shows the enteron first appearing as a slit at the junction of the animal and vegetable pole. It increases in length by the inturning of the epibolic cells as they grow over the yolk cells.

Vertical section of Egg



GASTRULATION.

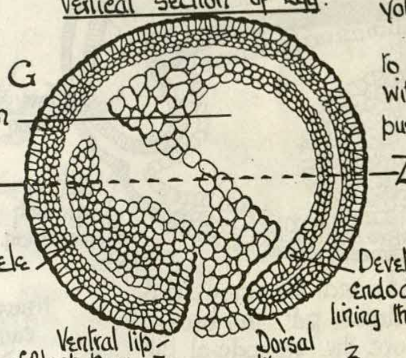
Under surface showing shifting of Blastopore through 100°.

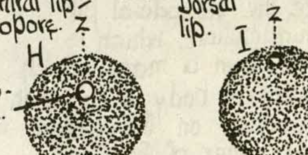


In G, the egg is about to begin its rotation. The horns of the crescentic blastoporic slit have met and closed, so forming the circular blastopore, which is plugged with yolk.

The yolk cells are heavy, owing to the amount of food they contain, with the result that when they are pushed to one side by the development of the enteron and the obliteration of the blastocoele, they cause the egg to capsize or topple over through an angle of 100°.

Vertical section of Egg.

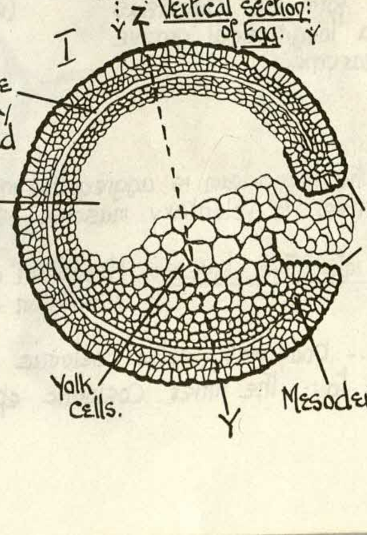




I shows the stage in which gastrulation is complete, having been brought about by the overgrowth of the ectoderm cells and the ingrowth of the blastoporic lips.

Here the enteron is well established, while the blastocoele has practically disappeared. Mesoderm formation is taking place rapidly, and the egg has completed its rotation with the result that the blastopore marks the future posterior end of the embryo.

Vertical section of Egg.

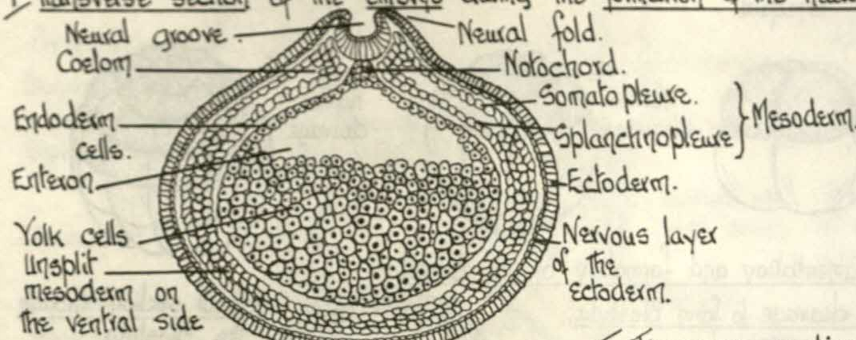


M.W.M.J.

Formation of the Mesoderm, Notochord, and Nervous system

In Frog, the mesoderm does not arise by the formation of enterocoelic pouches as in Amphioxus, but by the budding off of cells in the region of the blastoporic lips. These cells migrate inwards, between the ectoderm and endoderm, on either side of the mid-dorsal line. In addition to these, yolk cells lying beneath the ectoderm become differentiated as mesoderm, until eventually a complete mesodermal layer is formed between the ectoderm and endoderm.

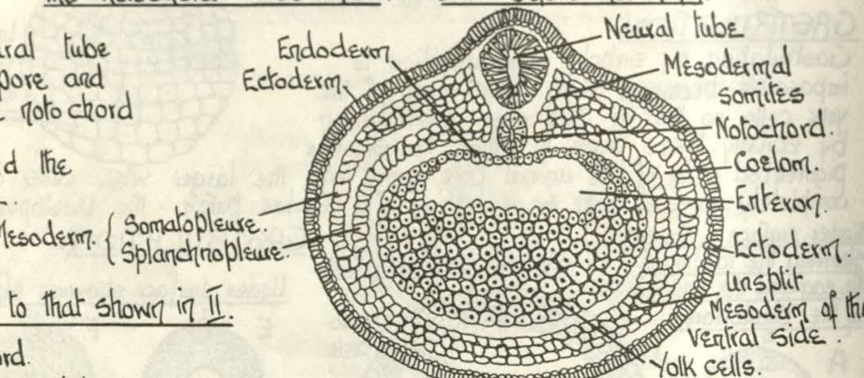
I Transverse section of the embryo during the formation of the neural canal, notochord and coelom.



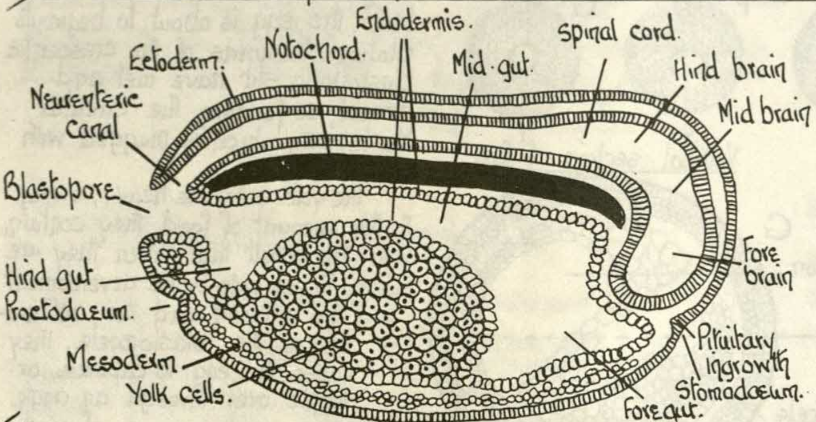
I Here the formation of the neural folds is seen extending along the back, down the whole length of the embryo, and just beyond the region of the blastopore.
The notochord is also developing as a groove rising from the endoderm along the dorsal surface of the enteron.

II Transverse section of the embryo, with the neural tube closed, and the notochord established. - Just before hatching.

II Here the neural folds have met to form the neural tube which remains in communication with the blastopore and enteron by means of the neurenteric canal. The notochord groove has closed to form a compact rod.
The beginning of the coelom is established, and the mesodermal somites have made their appearance.



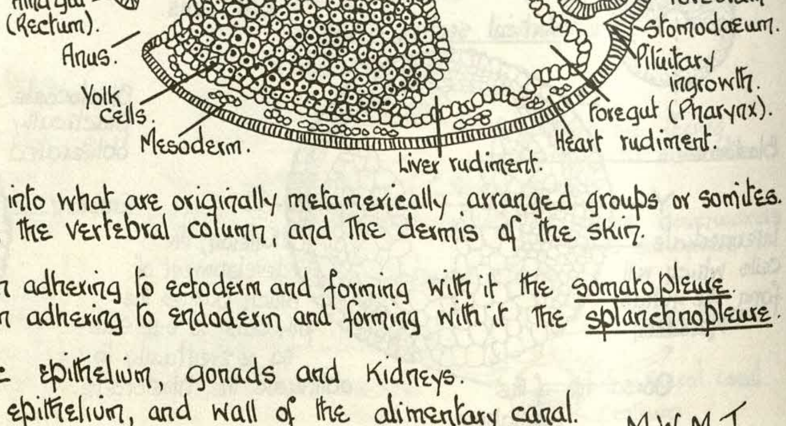
III Longitudinal section of embryo at a similar stage to that shown in II.



III This shows the neural tube swelling anteriorly to form the brain. The slight constrictions mark the three cerebral vesicles, which later develop into the fore, mid, and hind brain. The notochord terminates anteriorly in the region of the mid-brain, and extends posteriorly as far as the neurenteric canal.

IV Longitudinal section of the embryo, after the Blastopore has closed.

IV Here the blastopore has closed, and the ectodermal invagination forming the proctodaeum pit has broken through to form the anus. Above the stomodaeal pit an upgrowth fuses with the infundibulum, which is a downgrowth from the brain, to form a mass, which later separates and forms the pituitary body of the adult.
The downgrowth of the endoderm on the ventral side of the enteron is the forerunner of the liver, while the diverticula behind form the pancreas.
The thyroid originates as a longitudinal groove along the floor of the pharynx.



Somites are formed where the mesoderm is aggregated into what are originally metamerically arranged groups or somites. These somites give rise to voluntary muscles, the vertebral column, and the dermis of the skin.

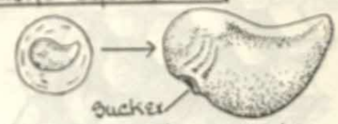
Remaining mesoderm splits into two layers:- Mesoderm adhering to ectoderm and forming with it the somatopleure.
Mesoderm adhering to endoderm and forming with it the splanchnopleure.

Somatopleure gives rise to:- body wall, outer coelomic epithelium, gonads and kidneys.
Splanchnopleure gives rise to:- the inner coelomic epithelium, and wall of the alimentary canal.

M.W.M.J.

Embryo before hatching

1.



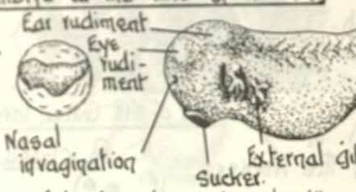
Gill or pharyngeal clefts are formed as evaginations of the endoderm lining the Alimentary canal. At the points where these pouches meet the ectoderm, the latter becomes perforated so forming the slits. The arches on either side of the slits correspond to the Hyoidean, Mandibular, 1st, 2nd, 3rd, 4th Branchial arches of the Dogfish. The Hyoidean in Frog is never concerned with respiration, but eventually forms the Eustachian tube of the adult.

When the egg is hatched, about two weeks after fertilisation, the tadpole which emerges breathes first by external gills, which are outgrowths from the skin. These gills are well supplied with blood and are ciliated.

At this stage the stomodaeal invagination has not broken through, so that no mouth is present. When freed from the gelatinous envelope, the tadpole attaches itself by a sucker, and remains so for about twenty-four hours.

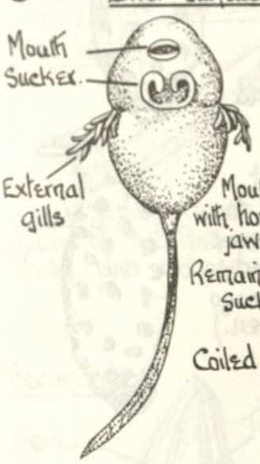
Embryo at the time of Hatching.

2.

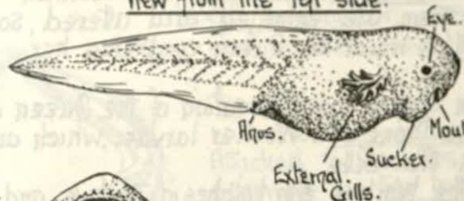


Tadpole with external gills

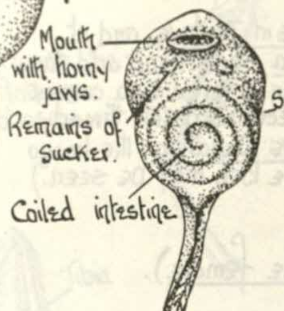
3 Lower surface



View from the left side.

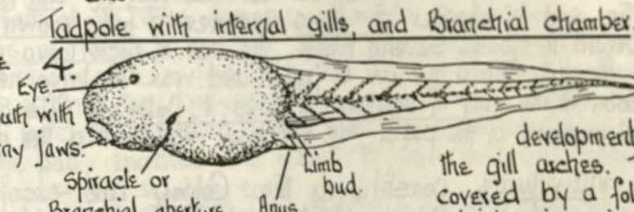


A little later the circular mouth appears, as a result of the perforation of the stomodaeum through to the enteron. The large lips are provided with horny papillae, which are especially adapted for scraping off minute plants from stones etc, so that the diet is purely vegetarian. During this period the animal is provided with a long coiled alimentary canal which is necessary to cope with the more bulky food.



Tadpole with internal gills, and Branchial chamber.

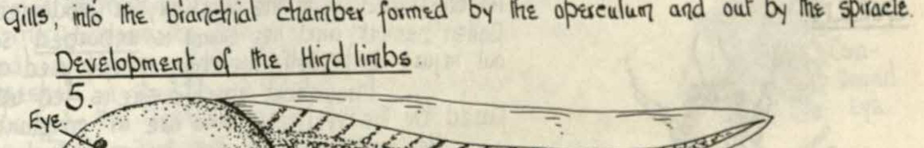
4.



The next stage shows the disappearance of the external gills, and the development of the internal gills between the gill arches. The whole on either side is covered by a fold of skin or operculum, which arises in front, grows back over the gills, and fuses posteriorly with the body wall, except for the small aperture on the left side - namely the spiracle. Water enters by the mouth, passes down the pharynx, over the gills, into the branchial chamber formed by the operculum and out by the spiracle.

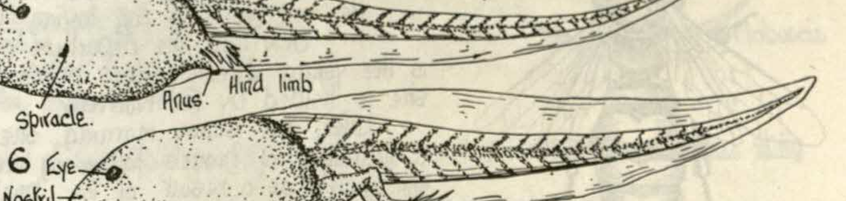
Development of the Hind limbs

5.



The tadpole increases in size, loses its herbivorous habit, and becomes carnivorous. The alimentary canal shrinks and the hind limbs make their first appearance as knobs or limb-buds, at the junction of the body and tail, on either side of the anus. These elongate and their extremities show the formation of the five digits, typical of the adult limb.

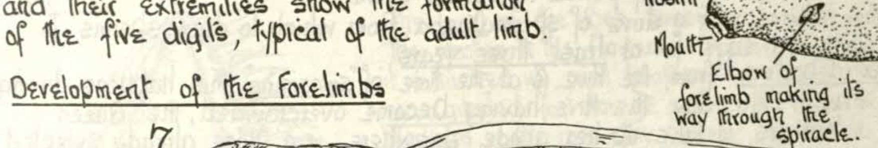
6



Development of the Forelimbs

Now the forelimbs make their appearance by penetrating the spiracle on the left side, and tearing the operculum on the right side. Their early development is obscured for some time by the opercula.

7.



Metamorphosis About three months after fertilisation, when the development of the four limbs is well established, the tadpole comes to the surface of the water periodically to fill its lungs with air, so that at this stage it breathes partly by the gills and partly by the lungs.

Finally, the gills wither away, and the operculum disappears.

At this stage, the appearance is frog-like except for the tail, which persists for some time.

8.

9.

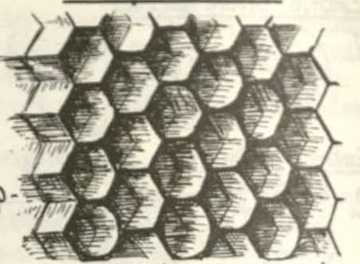
Later the tail is absorbed by the internal action of the phagocytes of the blood. Its disappearance is the indication that metamorphosis is completed.

The head now appears flattened, the eyes enlarge and become bulging, while the mouth widens, and the body grows less rotund.

M.W.M.J.

THE LIFE HISTORY OF THE HIVE BEE - APIS MELLIFICA. I

Honeycomb Cells



Cell of the Queen larva

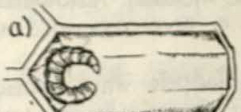
Closed.

Open.

1 EGGS. Small bluish white eggs are laid singly in the wax cells of the Honeycomb.
As the Queen deposits the egg, it is fixed to the bottom of the cell by a sticky secretion.

2. LARVA.

a)



b)

3. PUPA.

Unfertilised eggs develop into Drones (males)
Fertilised eggs develop into Workers, and more rarely Queens.
The wax cells of the Honeycomb, show slight variation, according to whether they store food or act as cradles for the developing larvae.

The cells containing the Drone larvae are larger and thicker walled than those which contain Worker larvae.
Whether the fertilised eggs develop into Worker (sterile female) or Queen (fertile female) larvae, appears to depend entirely upon the Workers.

Those which are destined to become Queens, receive special attention and diet, while the cells containing them are enlarged and altered, so as to form the irregularly oval cell, in which the Queen completes her development.

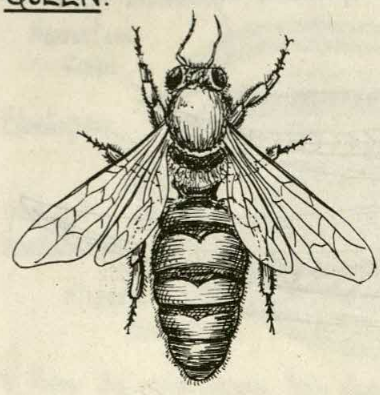
At the end of the season, before the Hibernation of the Queen and her Workers, the latter kill off all the Drone and Worker larvae, which are still undergoing development within their cells.

During the Honey harvest the Worker egg hatches in 3 days, and at the end of another 5 days, becomes a fully grown larva, with head and thirteen segments. During this period it moults several times. The cell of each larva is then covered by a convex cap, which is a porous mass, formed from a mixture of pollen and wax. The larva next secretes a silk thread, and makes an imperfect cocoon. At the end of another 2 days, it pupates. After 8 days pupating, the Imago emerges. (Through the pupal covering of the pupa, the external features of the mature Bee may be seen.)

4. IMAGO. The three individuals constituting the Colony are:-
Queen (fertile female); Drone (fertile male), Worker (sterile female).

The Queen is the supreme individual of the Bee community.

QUEEN.



As compared with the Worker, her abdomen is longer and her wings shorter. She carries no pollen basket, and her sting is unbarbed, so that it may be withdrawn from the victim, without injury to herself. The sting is only used against another Queen, who may prove to be a rival.

Throughout her life, she is fed upon partially digested food, provided and prepared by the Workers, who are in constant attendance.

Her sole work is egg-laying, which she does at a rate of one thousand per day.

Only after the departure of the reigning Queen, who leads the first "swarm", is the young Queen (oldest "princess"), allowed to emerge from her cell, in which process she is helped by the Workers.

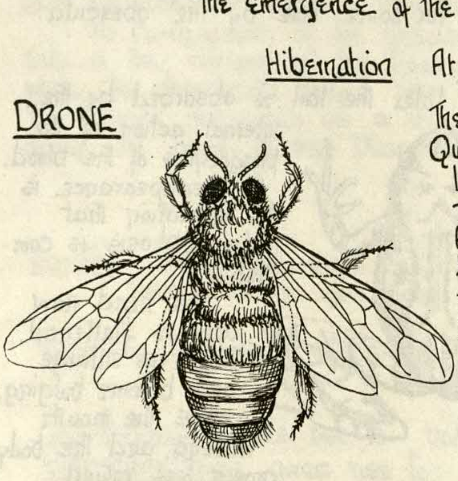
Later, one sunny morning, she emerges to take her Nuptial flight. She soars high, a multitude of Drones following her. Finally, one succeeds in mating with her, only to die immediately as a result of the brief period of sexual union.

The Queen then returns with a store of spermatozoa, from which to draw sperms, to enable her to fertilise her eggs for at least three years.

Her only other departure from the Hive is at the time of "swarming". This happens during the morning of one warm May or June day. The Hive having become overcrowded, the Queen emerges, accompanied by a swarm of Workers, to take up her abode elsewhere in a place already selected and prepared by "scouts" (advance guard of Workers).
Should the Hive still be overcrowded, her successor who has just emerged from her cell will lead a second swarm.
The emergence of the new Queen, and the nursing of the Drone and Worker larvae, is accomplished by the army of Workers who remain behind.

Hibernation At the end of the season, the reigning Queen hibernates until the following spring.

DRONE



The Drone develops from an unfertilised egg, and in build is bigger and broader than either Queen or Worker. The proboscis is short and feeble, while pollen baskets and sting are absent.
In the average Hive community, there is one Drone to every 6 or 8 Workers.
They emerge in the sun occasionally, but spend much of their time in sleep.
Apart from the vigorous attempts they make to fertilise a Queen, they do not perform any work in the general service of the Hive.
The Drone which does succeed in mating with the female dies immediately.
Drones, like the Queen, can only partake of partially digested food, and for the provision and preparation of this, they are dependent upon the Workers.

At the end of the Honey harvest, they are driven from the Hive by the Workers, only to die of cold and starvation.

Those which remain within the Hive are bitten to death by the Workers.
As a result, no Drone survives the Winter.

M. W. M. J.

WORKER

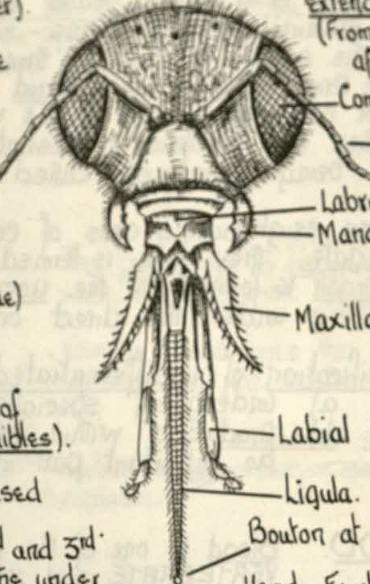
Each Worker possesses head, thorax and abdomen (gaster). The head bears at the side, a pair of large and conspicuous compound eyes, and three simple eyes situated in the centre of the forehead.

The freely movable antennae are probably a means of communication between Bee and Bee, while the numerous hollows over the surface are regarded as both Olfactory and Auditory in function.

The Mouthparts which consist of Proboscis (Labium or lower lip and Maxillae) Labrum or upper lip and Mandibles. show adaptation for

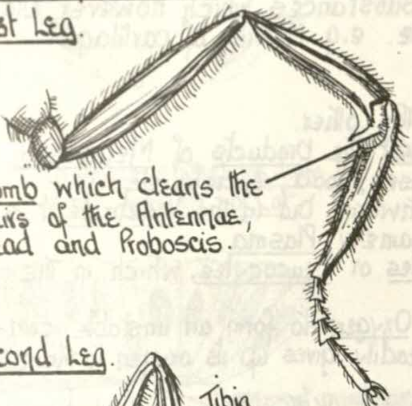
a) sucking (Proboscis)
b) cell construction in the Hive, preparation of wax, and the kneading of pollen (Mandibles).

Head and Mouthparts (Proboscis extended). (From Borradaile after Chesters)



Legs of the Worker. (partly after Lulham).

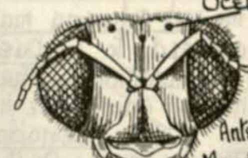
First Leg.



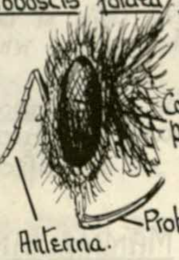
The thorax consists of three segments fused with the first abdominal segment. Attached to the dorsal surface of the 2nd and 3rd segments are two pairs of wings, while the under surface of the three thoracic segments bears three pairs of legs. Each leg is the typical Insect type, and terminates in two long and two short movable claws with a small pad between them. The claws enable the Bee to climb and cling firmly, while the sticky secretion of the pad, enables the insect to walk over very slippery surfaces with relative ease.

In addition to these features they possess characters which show special adaptations to perform functions associated with pollen and nectar collecting.

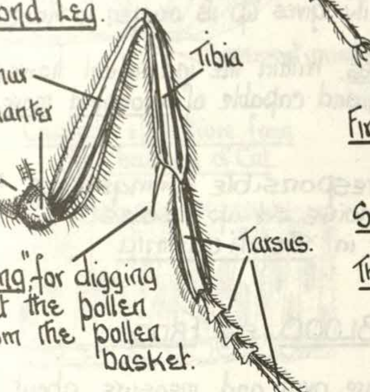
Head - Front view.



Head - Side view Proboscis folded back



Second Leg.



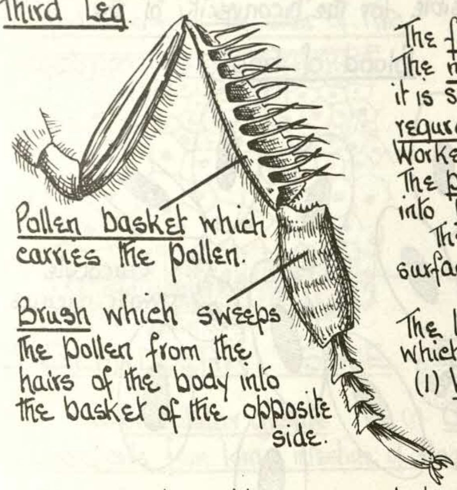
First Leg. has a small depression lined with hairs. and known as the "comb", which cleans the pollen from the hairs of antennae, the head, and the proboscis.

Second Leg. possesses a stout "prong", used for digging out the pollen from the pollen basket, and for preening the Wings.

Third Leg. bears a "pollen basket" and "brush". The basket carries the pollen as it is collected by the Bee, and the brush sweeps the pollen from the hairs of the body into the basket of the opposite side.

The Abdomen consists of five distinguishable segments, and at its tip bears a barbed sting

Third Leg.



The food of the Bee consists of pollen (proteid) and nectar (carbohydrate). The nectar in the flower is thinned by the action of the salivary juice of the Worker, after which it is sucked up, and temporarily stored in the Honey stomach. On the return to the Hive, it is regurgitated for storage within the cells as Honey, or may be used directly as food by the hungry Workers in the Hive, the Queen or Drones.

The pollen is dug out of the baskets and placed into cells, where it is kneaded with a little Honey into Brood Bread.

The young Workers secrete wax, which occurs as four pairs of wax scales on the under surface of the abdomen from which they gradually emerge below the segments.

The older Workers hollow out, and mould the wax.

The longevity of the Worker hatched in the Summer is usually from 4 - 6 weeks, during which time they perform a series of tasks in orderly succession.

(1) When they first emerge, they clean the wax cells, and attend the older larvae, providing them with pollen and Honey.

(2.) When 10 days old, they care for the very young larvae, feeding them upon a nutritive fluid secreted by themselves.

(3) When 14 days old, they spend their time in the general service of the Hive, cleaning away all refuse, distributing and storing the food, and ventilating the Hive by the rapid movement of their wings in flight within the Hive.

(4) When 21 days old, they emerge taking trial flights, and act as sentinels at the entry to the Hive, preventing the entry of intruders.

(5) The remainder of their lives is spent in collecting pollen and Honey.

Hibernation. At the end of the season any remaining Workers in the Hive snuggle together around the Queen, the Head of one underneath the Abdomen of another, in much the same way as tiles cover a roof. They beat their wings for ventilation, and feed on the Honey within the cells, passing it from one to another.

The Queen begins egg-laying in February, and by April, the life of the Hive, is once again in full swing. M.W.M.J.

HISTOLOGY - CELLULAR STRUCTURE OF ANIMAL TISSUES

The Cell unit is a minute mass of Protoplasm, bounded by a membrane and containing within its substance a deeply staining granular mass - namely the Nucleus, the protoplasm of which is specialised, in that it controls the activity of the cell throughout its life.

The term Protoplast or Energid has a wider meaning, since it can be applied to every protoplasmic unit, whether or not it possesses a cell wall.

When one nucleus is present, the cell is uninucleate; when several are present, it is multinucleate - the latter being sometimes called a coenocyte.

When neighbouring cells of common origin become similarly modified to perform the same function, the aggregate they form is termed a tissue. e.g. Muscular tissue.

An Organ is formed by the accumulation of different tissues, working in harmony with each other and working under the direct or indirect control of the Nervous system.

Modification of undifferentiated cells to form a tissue takes place either by the cells
a) undergoing specialisation to perform the work - e.g. Gland tissue. or
b) producing within or around them non-living and inert substances, which however play an important part in the function of the tissue as a whole. e.g. Matrix of cartilage.

1. BLOOD.

Blood is one of the liquid tissues of the body, lymph being the other. VERTEBRATE and INVERTEBRATE blood both serve to conduct the products of Metabolism about the body. e.g. Gases, food, excreta etc.

The red colouring matter - Haemoglobin is in solution in Invertebrate blood - e.g. Earthworm, but in the Vertebrate it is confined to Corpuscles, which float in the straw-coloured liquid medium - namely Plasma.

In addition to the Red corpuscles, Vertebrate blood contains White Corpuscles or Leucocytes, which in the healthy animal are much less numerous than the Red ones.

The Haemoglobin is important for Respiration, in that it combines with the Oxygen to form an unstable compound - namely Oxyhaemoglobin. On distribution to the tissues, this compound readily gives up its oxygen to them, while the Carbon dioxide is absorbed from them in the process of diffusion.

The White Corpuscles or Leucocytes are similar in most groups of Vertebrates. Within the individual however, they differ in both form and behaviour. As a rule, the protoplasm is evenly granular, and capable of amoeboid movement. The nucleus which is always present likewise differs in shape and size.

The most important white corpuscles are the Phagocytes, since they are responsible for ingesting the Bacteria which having gained entrance into the blood stream would otherwise set up disease.

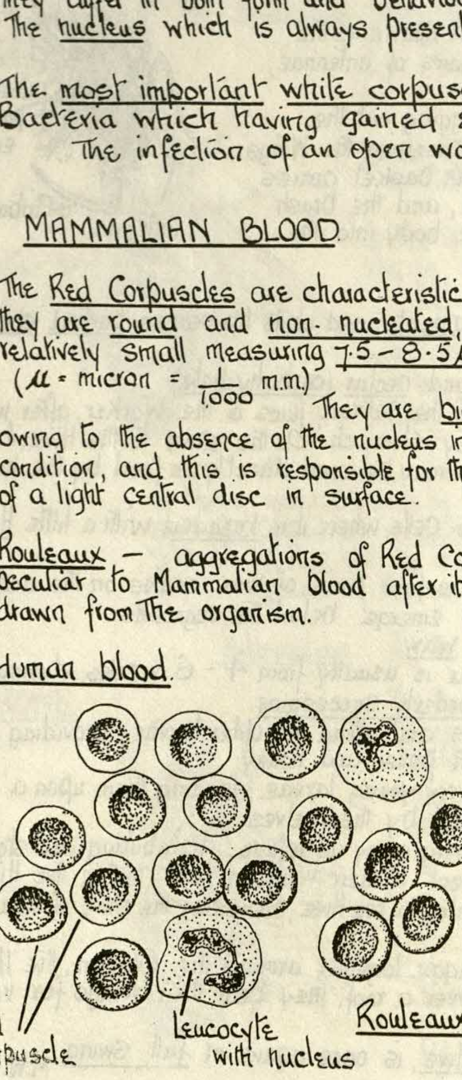
The infection of an open wound by such Bacteria frequently results in Septicaemia

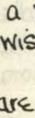
MAMMALIAN BLOOD.

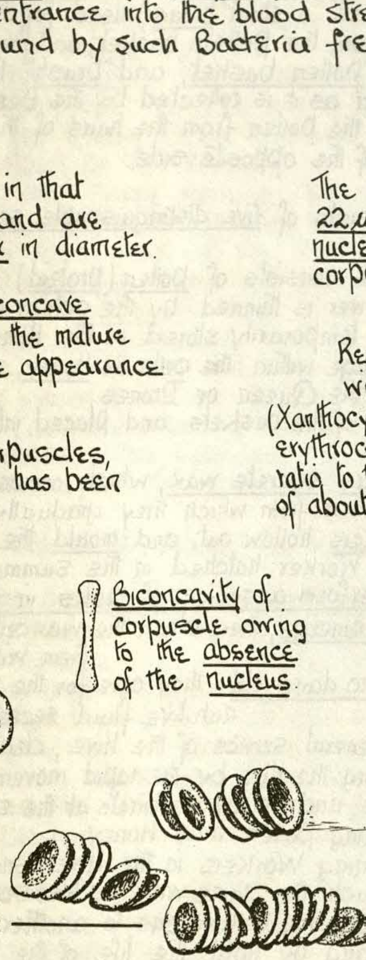
The Red Corpuscles are characteristic in that they are round and non-nucleated, and are relatively small measuring 7.5 - 8.5 μ in diameter. (μ = micron = $\frac{1}{1000}$ m.m.) They are biconcave owing to the absence of the nucleus in the mature condition, and this is responsible for the appearance of a light central disc in surface.

Rouleaux - aggregations of Red Corpuscles, peculiar to Mammalian blood after it has been drawn from the organism.

Human blood



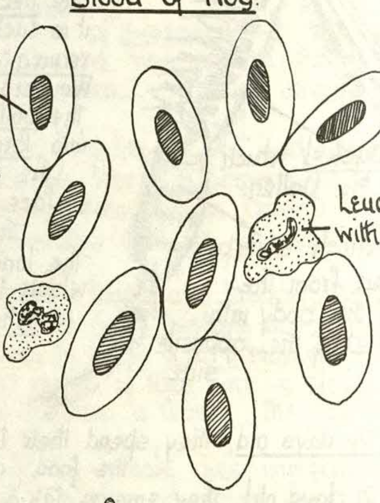


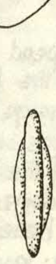


AMPHIBIAN BLOOD. e.g. FROG.

The Red Corpuscles are oval, and measure about 22 μ x 16 μ. The presence of the large deeply staining nucleus is responsible for the biconvexity of the corpuscle

Blood of Frog.





M.W.M.J.

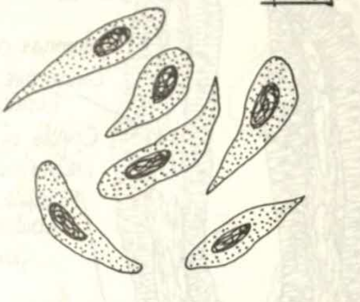
2. EPITHELIAL TISSUE

An epithelium is a layer of cells which covers the body and lines any spaces (e.g coelom) which it might contain. It is of two kinds:-
a) simple epithelium consisting of one layer of cells.
b) Compound epithelium of more than one layer of cells.

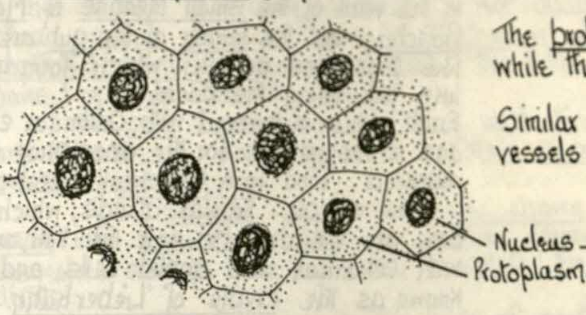
a) Simple epithelium.

(i) Squamous or pavement epithelium.

Isolated cells from the mouth of Frog.



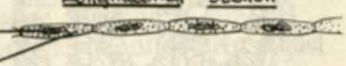
Cast skin of Newt. (surface view)



The protoplasm is finely granular, while the nuclei are large and round.

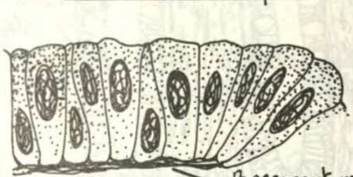
Similar tissue lines the blood vessels and the coelom.

Longitudinal section



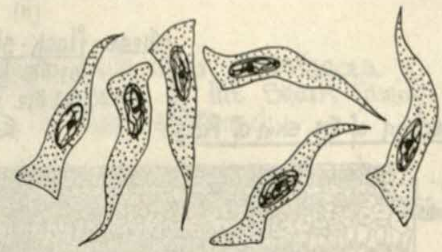
(ii) Columnar epithelium.

Columnar epithelium from the small intestine of Cat.



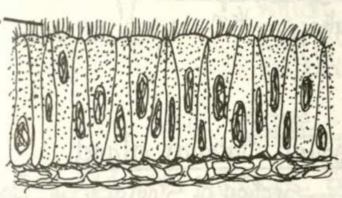
This type of cell lines the greater part of the Alimentary canal.
The elongated cells stand side by side on the basement membrane, and are closely applied to each other.
The nuclei are large and stain deeply.

Isolated cells from the intestine of Frog.



(iii) Ciliated epithelium.

Ciliated epithelium from the Trachea of Cat.

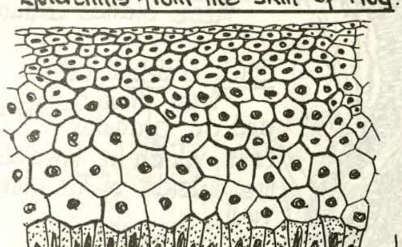


These cells have the usual columnar form, while the free edge away from the basement membrane bears densely crowded cilia.
This tissue is found in the roof of the mouth of Frog, where it causes the mucus of the mouth to flow down the oesophagus, so facilitating the process of swallowing.
In the Trachea of Cat, the cilia are responsible for the upward current of mucus by which foreign matter, likely to pass to the lungs, is expelled.

b) Compound epithelium

(i) Stratified epithelium.

Epidermis from the skin of Frog.



Occurs chiefly on the body as the epidermis of the skin.
Several layers lie on the basement membrane - the lowest cells are the largest and possess big nuclei. These cells are constantly dividing, and so give rise to more superficial, which gradually become flatter as they approach the surface.
The uppermost layer consists of flat cells or squames, which overlap and constantly rub off, while their place is taken by others recruited from the lower layers.

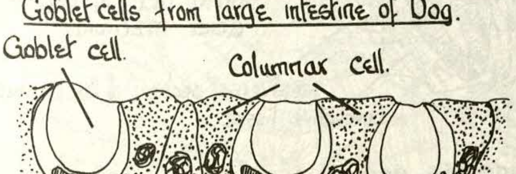
3. GLANDULAR TISSUE

- The importance of these cells lies in their power to secrete substances, which are necessary for the general metabolism of the body.

a) Unicellular glands

(i) Goblet cells.

Goblet cells from large intestine of Dog.



These are isolated cells intermingled with columnar cells, which line the large intestine of Mammals. These goblet cells are responsible for the secretion of mucus, which is necessary for the lubrication of the Alimentary canal.
Mucus occurs within the cells as granules, which when discharged forms the mucus. This gives to the epithelial lining the name "mucus membrane".

After the discharge of the mucus, there appears in the cell - a cup-shaped hollow - hence the name "goblet cell".

M.W.M.J.

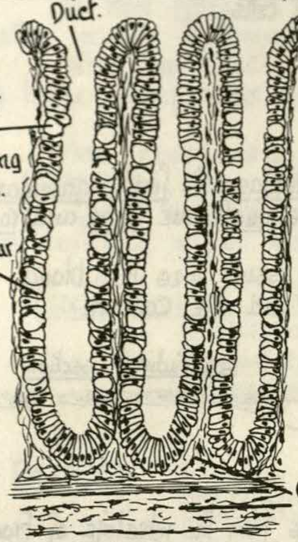
HISTOLOGY - CELLULAR STRUCTURE OF ANIMAL TISSUES.

GLANDULAR TISSUE. (continued)

b) Multicellular glands. (i) Simple Tubular gland.

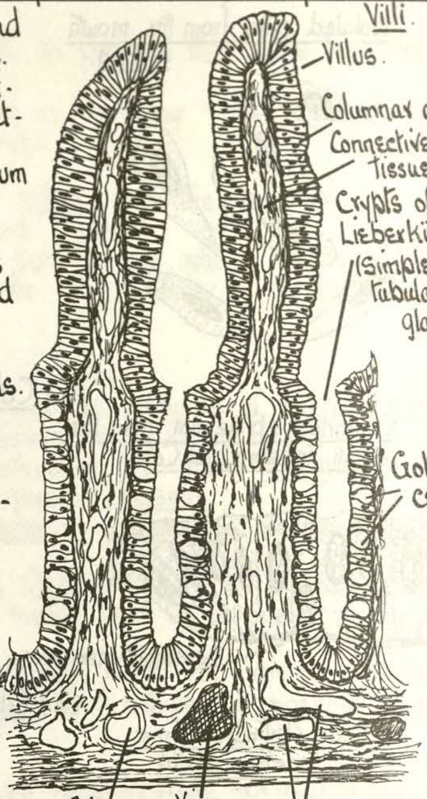
Here glandular cells are grouped together in such a way that their secreted products can be poured into a receptacle, which opens to the exterior by a single tubular duct.
Glands of this type line the wall of the large intestine of Mammals.

Section of Large Intestine of Dog.



Modification of the simple tubular gland found in the wall of the small Intestine of Mammals. Projecting into the lumen of the gut are finger-like processes or Villi, which form a velvet-like pile lining the canal.
Each villus is covered with columnar epithelium and is responsible for the absorption of digested food from the small Intestine.
The simple tubular glands, which in this case are situated between the Villi, are lined with columnar and goblet cells, and are known as the crypts of Lieberkühn. The latter secrete mucus.

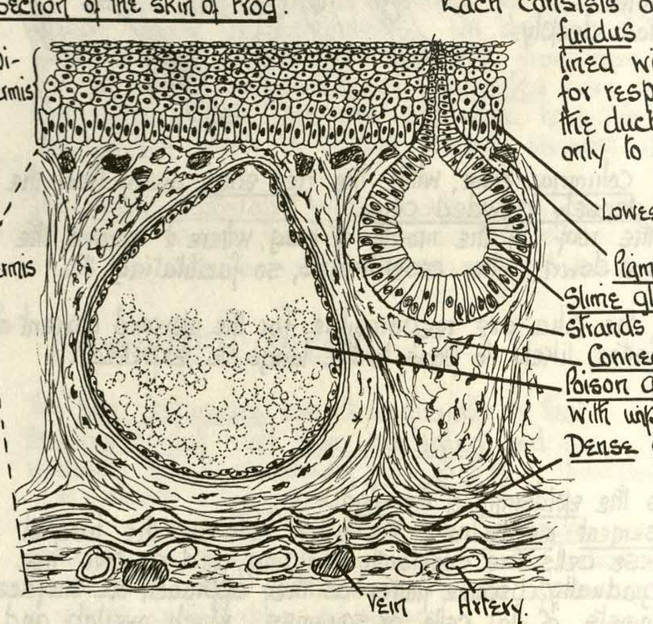
Section of the small Intestine of Cat showing Villi.



(ii) Simple Saccular gland.

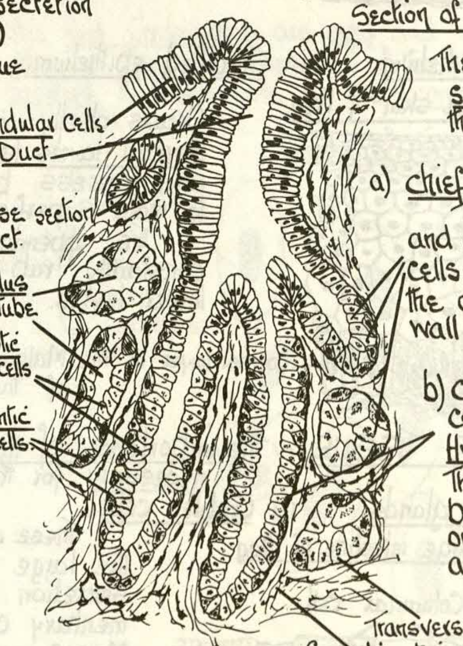
These flask-shaped glands in the skin of Frog are of two kinds:-
(1) the large granular poison gland,
(2) the smaller slime gland.
Each consists of a round basal portion or fundus and the duct. The fundus is lined with glandular cells, and is therefor responsible for the secretion, while the duct being non-glandular, serves only to carry the products of the fundus to the exterior.

Section of the skin of Frog.



(iii) Compound Tubular gland.

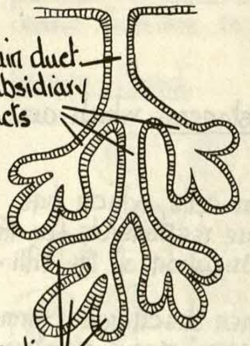
Section of Stomach of Dog.



The fundus or secretory part of these glands contains:-
a) chief or peptic cells - these produce Pepsin, and are granular ovoid cells, which lie towards the outside of the gland wall
and
b) clear cubical oxyntic cells, which secrete Hydrochloric acid. The latter is essential because Pepsin will only act in an acid medium.

(iv) Racemose gland.

Diagram of a Racemose gland.



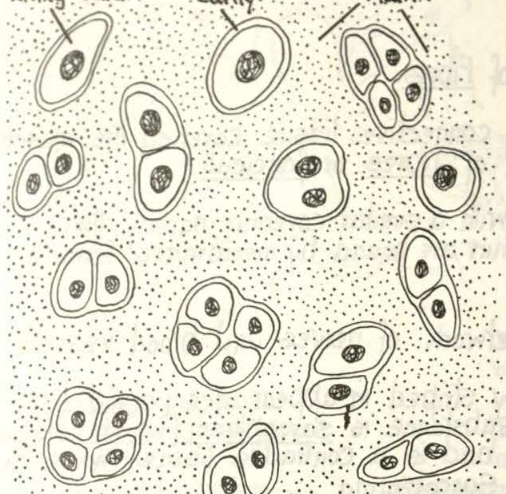
Further modification of the compound tubular gland, in which each branch is divided up into a series of bulbous chambers or Alveoli. The glandular cells are confined to the Alveoli, where they occur as groups or Acini.
The secretion of such is poured into the subsidiary tubules, and finally into the main duct which opens to the exterior.
When the Alveoli are very numerous, as in the pancreas and salivary glands, the parts are bound together by connective tissue (well supplied with nerves and blood vessels) to form a compact organ.

M.W.M.J.

4. CONNECTIVE TISSUE

- This is responsible for the
  a) binding together of various parts e.g. Mesentary, Areolar tissue or
  b) support of any organ. e.g. Skeletal parts.

(i) Cartilage.



Commonly known as gristle. This tissue constitutes the whole part of the Dogfish skeleton, and a considerable part of that of Frog.

The simplest form is Hyaline cartilage. A thin section of Hyaline cartilage is not opaque to light, and consists of an organic ground tissue or Matrix, in which are small irregularly scattered cavities containing cells. The latter are either solitary, in pairs, or in groups of four.

The cells themselves are living and throughout their existence are capable of dividing, and by their secretory power, are able to produce new matrix.

The solitary cells when fully grown divide into two, and again into four. These four, by further formation of matrix around themselves separate from each other complete their growth and then again divide.

Hence the increase in the bulk of cartilage.

There are no passages between the cells, so that any transference of substance is by diffusion through the matrix.

Modification of Hyaline cartilage is dependent upon the impregnation of the matrix with other substances.

Calcified Cartilage. Matrix is impregnated with Calcium carbonate, as in members of the Shark family, in which the cartilaginous skeleton is thus stiffened.

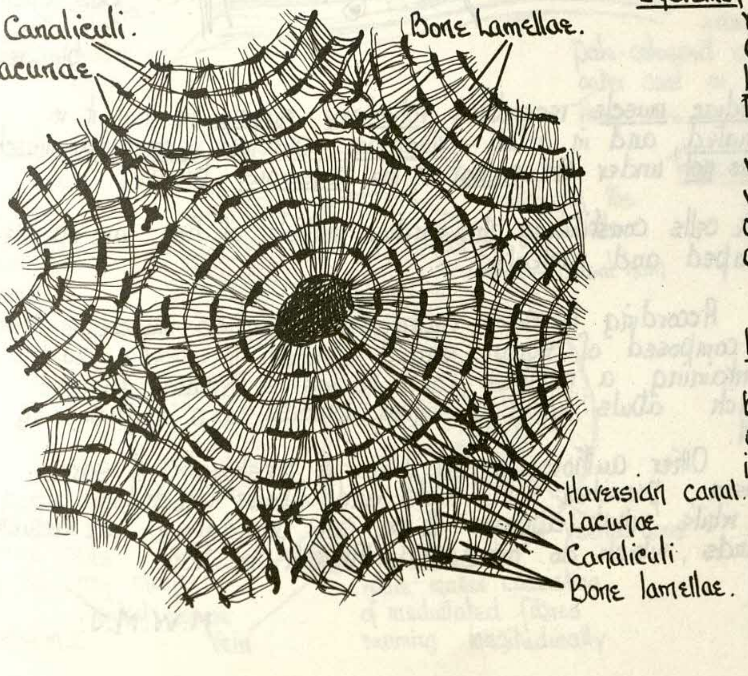
Elastic Cartilage. Running through the matrix are yellow elastic fibres, which anastomose throughout the matrix. Such cartilage is characterised by its elasticity, and is found in those parts which must necessarily be flexible. e.g. Outer ear of Mammals.

Fibro - Cartilage. The toughness of the matrix here is due to the presence of white inelastic fibres which render the whole capable of withstanding considerable pressure. It is found between the articulatory surfaces of joints, and between the centra of the vertebrae, which are parts subject to great pressure.

(ii) Bone.

The strength and hardness of this tissue is due to the fact that the substance is impregnated with inorganic salts. The bulk of it consists of a matrix, in which the cells are regularly arranged. About one-third of the matrix consists of a similar organic subtance to that of cartilage, while the remaining two-thirds is of an inorganic nature, containing salts - the most prevalent of which is Calcium phosphate.

Transverse section of Bone.



Transverse section of Bone shows a series of units known as Haversian Systems, each with a central Haversian canal. Within this canal run the blood vessels, nerves, and lymphatics. Concentrically arranged are the smaller spaces or Lacunae, while the concentric rings of bone between them are the Bone Lamellae.

Running through the Lamellae are the Canaliculi, - ramifying channels containing protoplasmic threads which pass between the Lacunae of one ring, and those of the adjacent ring, so forming a means of communication between the living cells of the Lacunae.

The bone cells or Corpuscles are confined to the Lacunae.

The Haversian systems do not remain isolated but branch so that there is an adequate distribution of nerves, blood vessels and lymphatics, throughout its substance.

M.W.M.J.

5. MUSCULAR TISSUE.

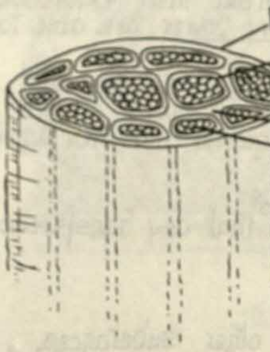
- much of which is responsible for the movement of skeletal tissues to which it is attached by tendons. Its power is dependent upon its contractility.

It occurs in three forms:-

(i) Striped, striated or voluntary
(ii) Unstriped, unstriated or involuntary
(iii) Cardiac.

(i) Striped, striated or voluntary muscle consists of elongated bundles of fibres.

Diagram to show the show the structure of the Muscle.



The Epimysium is the elastic connective tissue covering the muscle, which encloses the bundles of fibres or fasciculi.

Each fasciculus is provided with a similar covering namely the Perimysium, while the fibres within are bound by membranes forming the Endomysium.

Between the bundles run a network of nerves and blood vessels.

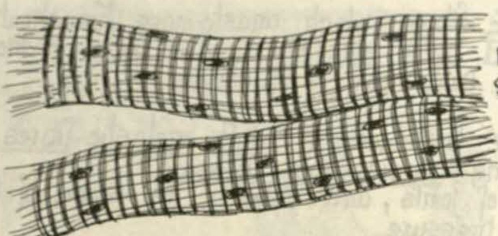
The fibres are characteristically striped in appearance (about 50 μ in diameter). The bulk of the substance is sarcoplasm (which consists of fine fibrils or sarcostyles) and is a contractile tissue, while the membrane covering it is the Sarcolemma.

The stripes are caused by alternating bands of light and dark across the substance of the Sarcoplasm.

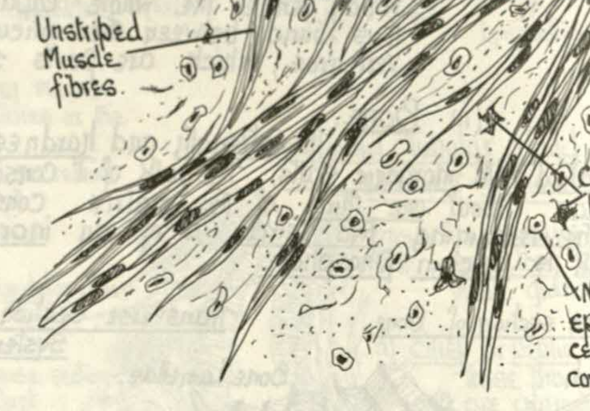
The nuclei occur just beneath the Sarcolemma.

The fibre may be regarded as a syncytium, in which there is no division into definite cells. It may be compared with a coenocyte.

Striated Muscle Fibres.



Bladder of Frog showing Unstriated Muscle.

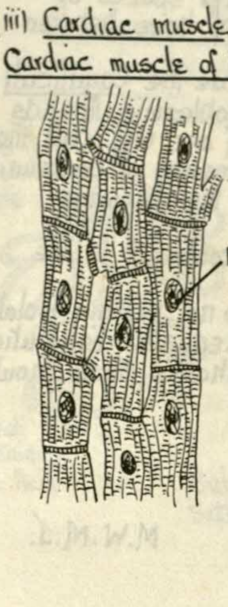


(ii) Plain, unstriped, unstriated or involuntary muscle, consists of tightly packed distinct spindle-shaped cells, with oval nuclei. Fibrils of Sarcoplasm run along the whole length of the cell, giving to it a faint longitudinal striation.

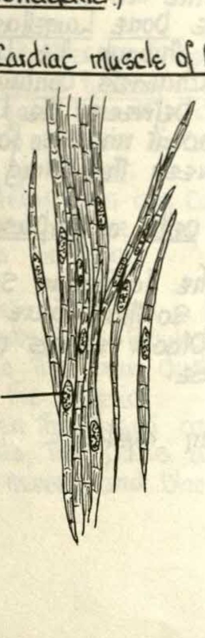
Each cell is provided with a delicate sheath. When they occur in masses, the cells are held together by an intercellular cement substance, across which run threads of protoplasm. These serve to keep the cells in continuity.

(iii) Cardiac muscle. (From Borradaile.)

Cardiac muscle of Man



Cardiac muscle of Frog



Cardiac muscle resembles voluntary muscle in that it is striated, and in action - vigorous, but like involuntary muscle, it is not under the control of the conscious brain.

The cells constituting the cardiac muscle of Frog are spindle-shaped and nucleated.

According to some authorities, cardiac muscle in Man is composed of square ended cylinder-like cells, each containing a nucleus, and having a peculiar process which abuts upon a similar process in a neighbouring cell.

Other authors regard it as a meshwork of sarcoplasm, provided with nuclei, and fibrils which run along it, while what appears to be cell boundaries are actually bands, which do not extend through the fibre.

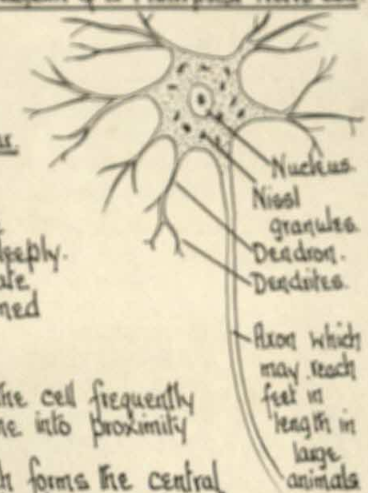
M.W.M.J.

6. NERVOUS TISSUE.

Consists of nerve cells, and their processes, which are responsible for the conduction of impulses from and to the Central Nervous System.

Nerve cells from the Spinal cord of Ox.

Diagram of a Multipolar Nerve Cell.



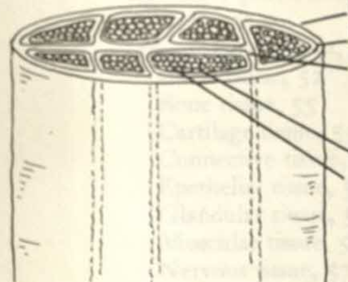
Nerve cells are found in the grey matter of the Brain and Spinal cord. They are large stellate cells, and are classified according to the number of processes which emerge from them as uni-polar, bi-polar and multi-polar. The latter are the prevalent type.

The protoplasm of the cell is granular, and the single nucleus is large and conspicuous. The deeply staining Nissl's granules frequently disintegrate after physiological activity, so that it is presumed that they are of a nutritive nature.

The processes or dendrons which emerge from the cell frequently break up into fine branches or dendrites, which come into proximity with those of adjacent cells.

The axon is the long undivided dendron, which forms the central portion of the nerve fibre, and is responsible for the transmission of impulses from the cell to the periphery.

Diagram to show the structure of a nerve.



Each nerve has an outer connective tissue coat or Epineurium, which encloses numerous funiculi, bound together by Endoneurium.

Each Funiculus has a protective sheath or Perineurium, and contains a group of Nerve fibres.

Nerve fibres are of two kinds - Medullated and Non-medullated.

Medullated fibres form the bulk of the principal cranial and spinal nerves.

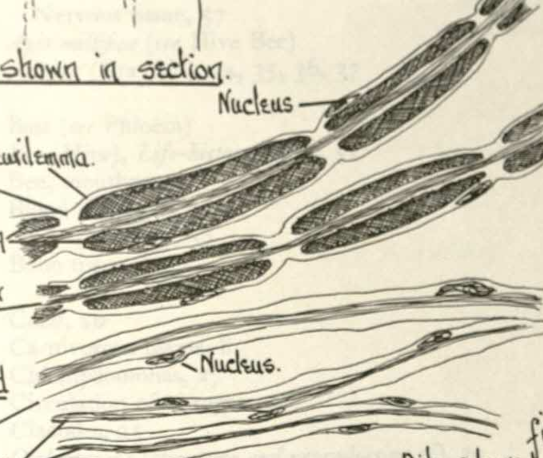
The long delicate axis cylinder is a continuation of the axon of the nerve cell. This is covered first by the fatty medullary sheath, and secondly by the outer thin transparent and tough Neurilemma.

The medullary sheath is interrupted at regular intervals, and the constriction of the Neurilemma at such points forms what are known as the Nodes of Ranvier.

The region between the nodes (internodes) are probably modified cells, since they each contain an elongated nucleus.

Medullated fibres branch only at their peripheral ends.

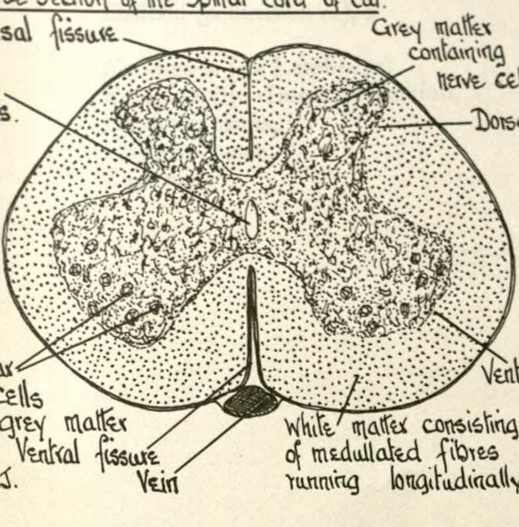
Nerve fibres shown in section.



Non-medullated fibres occur in small numbers in the Cranial and spinal nerves, but are the chief type of fibre found in the Sympathetic Nervous system. The nerves are pale-coloured and thin and have no medullary sheath, but possess the thin outer coat or Neurilemma.

They are nucleated along their length, and often branch.

Transverse Section of the Spinal cord of Cat.



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Transverse section of the nerve cord shows, on the outside, the Pia mater or connective tissue coat, which along the middle lines of the dorsal and ventral surface, passes in to some depth, as the dorsal and ventral fissures.

The central nervous tissue of the grey matter surrounds the canalis centralis, which ends blindly behind, but in front is continuous with the cavities of the brain.

In the grey matter are a large number of multipolar nerve cells, especially in the region of the ventral horns.

The dorsal and ventral horns give rise to the dorsal and ventral roots of the spinal nerves.

White matter surrounding the grey matter consists of medullated fibres running longitudinally along the cord.

The Neuroglia, which forms the groundwork is the connective tissue which supports and binds together the cells and fibres.

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Printed and Bound in Hong Kong by Wing King Tong Co. Ltd.
and published by John Murray (Publishers), Ltd.

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